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ABSTRACT

The study seeks to provide current empirical data for welding curriculum development and updating and for an occupational ladder. To secure information, a descriptive survey was conducted in Washington, Oregon, and British Columbia. A welder and welding supervisor in each of 58 responding industries filled out an in-depth questionnaire; the respondents represent both large and small industries hiring from 4 to 600 welders. Questionnaires filled out by 12 American Welding Society regional presidents assured the study greater validity. The questionnaire consisted of 36 questions divided into five sub-divisions: general information, basic education, welding-related knowledge requirements, welder-related skills and functions, and the manipulative skills required for a production welder. The analysis of the questionnaire is provided question-by-question within each section of the study, with the necessary data tabulation provided and referenced. Eleven recommendations for curriculum development emphasize the need for area surveys of needs, school-industry cooperation, development of an occupational ladder, more cooperative work-experience programs, and instruction of experienced welders to enable them to become on-the-job trainers of new welders. Extensive appendixes include copies of the questionnaires, information about and remarks made by the respondents, and a list of industrial concerns. (AJ)

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1974 WELDING TASK ANALYSIS

by

CHARLES FREDERICK BACON

A post masters degree study conducted for the purpose of updating welding technology curriculum at Everett Community College and for others with comparable needs.

UNIVERSITY OF WASHINGTON
1974

Under the direction of Dr. Athol R. Baily, Industrial Education professor, and with the cooperation of welding instructors at Everett Community College.

Approved by Athol R Baily Date Aug 15, 1974.

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1974 WELDING TASK ANALYSIS

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WELDER'S TASK ANALYSIS

CHAPTER I

INTRODUCTION

Every facet of human endeavor has been affected by the scientific advancement of our age. The methods and technology of the 1960's is no longer adequate for the fiercely competitive reality of the 1970's. The United States of America has exported its technology and treasure for the rebuilding of war torn nations. These nations in 1974 are technologically advanced and in many areas of technology are surpassing the United States. With an energy shortage facing this nation, it is imperative that our educational system be abreast of change.

This writer has conducted a task analysis of the welding occupation to provide empirical data from which relevant welding curriculums may be developed. Current welding occupational research does not exist. Job classifications do not accurately reflect "welding job" functions; therefore, the development of curriculum and the training of welders may or may not be relevant.

Purpose of the Study

This study seeks to provide current empirical data for welding curriculum development, updating and an occupational ladder.

Need for the Study

The need for this study has been demonstrated by the following reasons:

1. Lack of current research from which to build curriculum.
2. No well-defined occupational ladder within industry.
3. Lack of information concerning commonalities among the many facets of welding in the various metal industries.

Method of Research and Sources of Data

Method of Research. To secure current information for the training needs of welders the descriptive survey method of research was used. The descriptive survey was conducted in two stages. The first questionnaire requested industrial cooperation for an in-depth questionnaire to be filled out by a welder and a welding supervisor. (See Appendix A.)

Sources of Data. The sources of data for this study were production welders, welding supervisors, and welding literature from professional societies, government and educational agencies throughout the United States and Canada.

Two hundred and eighty letters of inquiry were mailed to industries of Washington State, Portland, Oregon and Vancouver, British Columbia. From this group eighty-five responses were returned of which fifty-eight desired further participation in the study. An additional twenty-nine copies were mailed to industries either not responding or were added to a revised mailing list.

To assure greater validity for the study twenty-two questionnaires were mailed to American Welding Society Regional presidents. From this mailing twelve completed questionnaires were selected for a control group. For additional data sources the writer has relied upon his welding-related experiences and observations. Letters and interviews with persons having expertise in the welding occupations have been invaluable.

Limitations

This welding technology task analysis of the welder is limited in the following ways:

1. The survey was limited to the geographic boundaries of Washington State, Portland, Oregon, and Vancouver, British Columbia.
2. The preliminary questionnaire of five questions was limited to two hundred and eighty (280).
3. The responses obtained from industry were limited to their willingness to answer and their personal knowledge.
4. The welding processes of concern for this study

were limited to oxy-acetylene Welding (OAW) and Cutting, Shielded Metal Arc Welding (SMAW), Gas Tungsten Arc Welding (GTAW), Gas Metal-Arc Welding (GMAW), and Flux Cored Arc Welding (FCAW).

5. The study has included limited research of current welding publications.
6. The study was limited to the industries employing welders.

Definition of Terms

The following definitions were provided to assure clarity regarding their usage throughout the study.

Welding. Welding is a localized coalescence of metals where coalescence is produced by heating to a suitable temperature, with or without the application of pressure, and with or without the use of filler metal. The filler metal either has a melting point approximately the same as the base metal or has a melting point below that of the base metal but above 800°F.

Welder. An operator of welding equipment or an operator who makes welds (preferred definition). (This preferred definition shall be used throughout this study). A machine for doing welding.

Weldor. An operator of welding equipment or an operator who makes the welds.

Welding Operator. One who does welding. A welding operator is generally referred to as a weldor. (Welder preferred.)

A.W.S. American Welding Society, 2501 N.W. 7th Street, Miami, Florida 33125.

A.S.T.M. American Society of Testing Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

NC No comment.

WS Welding Supervisors

NCG National Control Group

Overview of the Remainder of this Study

The development of this study has included Chapters II, III, IV, V, and VI, followed by a bibliography and appendix. Chapter II has presented a review of related research relative to this study. Chapter III has included a summary of the welder's tasks as reported by the welders' preliminary questionnaires. Chapter IV summarizes the questionnaire on welders. Chapter V summarizes and reports the questionnaire findings as reported by the supervisors of welders. The conclusions, recommendations, and future trends are also reported in Chapter VI.

CHAPTER II

REVIEW OF RELATED RESEARCH

The related research review for this study has been given three divisions: (1) history of welding, (2) literature related to welding analysis, and (3) summary of related studies.

History of Welding

This writer, in the development of his masters thesis, researched the history of welding, development of the gas welding process, arc welding, and other contemporary welding processes. This material is found in Chapter II, pages 9-18 (inclusive) of thesis.

Literature Related to Welding Analysis

The "Eric" computer search was unable to find current welding literature providing empirical data from which welding curriculums, welding job functions, or from which the occupational ladder could be developed.

The Bacon master's thesis 1964, Table IV, has provided relative training data for the welder in post high school curriculum. The study does not provided task analysis or occupational ladder data, but has provided for a comparative analysis for the current data on general education requirements, welding related knowledge, and general skills the welder should possess as reported by industry employing welders in the States of Washington and Oregon.

The Stemmer doctoral dissertation 1973, #10,* dealt with welder training proficiency as related to the multi-position verses the single position training approach. This study concluded there were no statistical veriations in the proficiency of training for the two methods.

The Welding Instructors Association of Washington completed a sixteen question interview type survey of Puget Sound industry employing welders during August 1973. This research was under the sponsorship of George P. Pilant, Research Specialist, Program Planning and Research, Coordinating Council for Occupational Education, Olympia, Washington 90504. The survey included questions relative to types of products manufactured, number of welders employed, their training background, and the welding trend anticipated within the next five years. The summary report was compiled by the "Evaluation Committee" for the welding instructors with Ken Miller serving as Chairman.

This two page report summary is hereby reported in its entirety.

> The various welding processes surveyed indicated that shielded metal arc, gas metal arc and gas tungsten arc (including plasma arc), are by far the most commonly used in industry. Projecting this information ahead five years, the majority felt that the demand for some type of gas

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*#10 - "The Stemmer doctoral dissertation, page 52."

metal arc process and personnel to operate the equipment would far surpass the requirements of all other processes. The survey indicated that shielded metal arc and gas tungsten arc will see little or no change and demand for the oxy-acetylene process as a manufacturing tool would decrease.

Industry ranked the oxy-fuel gas cutting applications in the following order, with a strong indication that students should be versed in all gasses: (1) acetylene, (2) natural gas, (3) propane, and (4) mapp gas. Acetylene would be considered the most practical gas for welding with the others used primarily for cutting, with each particular industry having a favorite depending on the requirements.

The survey indicated that students should be well-versed in the welding of both ferrous and nonferrous metals, with mild steel plate the most commonly used. In the future, the lighter but higher strength alloy steels will be used which will require instruction involving special welding procedures and techniques.

It was found that welding proficiency tests are varied and the demands of a particular industry or even a particular job would be the determining factor in deciding which test to use. The evaluating team would recommend that a student be able to weld in vertical, horizontal and overhead position on mild steel plate and would, therefore, be able to pass most entry level skill tests.

Most companies did not have specific information on preference of experienced over newly trained welders. Generally, it was noted that companies employing 100 or more welders hired as many as 25% recent trainees, while the smaller companies hired less than 10% recent trainees.

It was found that the ability to read prints, interpret welding symbols and read a rule were the skills that most companies desired in a welder. Lack of lay-out experience can be directly related to not being able to read shop drawings. To sum up the needs of related subjects listed, all were desirable in larger shops, but required in smaller shops.

None of the companies interviewed wanted to be in the welder training business. Therefore, they did not have a formal beginner welding training program in operation. However, many shops conduct special classes to upgrade their own employees or train potential employees to meet a particular demand in their industry.

Most companies have some mental or physical requirements for prospective employees. It is apparent that in the future, more companies will require a basic medical examination and a back x-ray.

It is very possible that a physically handicapped worker could find employment as a welder and most industries expressed willingness to hire him. However, it is possible, but highly unlikely, that a mentally handicapped person could find employment as a welder, even if he could pass the same entry level skill test that any other welder meets. Most companies would evaluate the degree of mental incapacity and judge on the specific disability. In no event would a person be hired who is a safety hazard to his fellow employees.

The survey showed need for welding technology, but most interviewed knew little of welding technician trainees. However, the opportunities for a welding technician are growing. It was indicated that many companies would desire a person with these skills and perhaps are using them in a supervisory capacity.

Since welding is not an apprenticeable trade, the welder is used in other trades such as boilermakers, iron workers, sheet metal and others, and joins the union that has the labor contract. It is generally recognized that the hourly rate and fringe benefits paid are higher in a union shop than a non-union shop.

In general, remarks were many and varied. It appeared that the overall training that a student receives was acceptable, but the companies wanted the student to be more versed in semi-automatic equipment such as the gas metal arc. Many in personnel found it difficult to find welders who are self-motivated and willing to take a positive attitude toward the company he represents and the product he manufactures.

As reported by the Occupational Outlook Handbook 1972-1973, there were 535,000 welders and oxygen and arc cutters throughout the country. Of this group there are 385,000 working on the manufacturing of durable goods, such as transportation equipment and fabricated metal products.

The welder trainee should be a person who:

A oung person planning a career as a welder or cutter needs manual dexterity, good eyesight and good hand-eye coordination. He should be able to concentrate on detailed work for long periods. He must be free from any physical disabilities that would prevent him from bending, stooping, and working in awkward positions. p. 573*

For entry in manual welding jobs most employers prefer to hire young men who have high school or vocational school training in welding methods. Courses in mathematics, mechanical drawing and blue print reading also are valuable.

The skilled welder plans and lays out work from drawings, blueprints or other written specifications. He knows the properties of steel, stainless steel, cast iron, bronze, aluminum, nickel and other metals and alloys. He also is able to determine the proper sequence of work operation for each job and to weld all types of joints in various positions (flat, vertical, horizontal and overhead). p. 572*

Employment of welders is expected to increase rapidly through the 1970's as a result of the generally favorable outlook for metal working industries and the wider use of the welding process. In addition to job openings created by employment growth, several thousand openings will arise annually because of the need to replace experienced workers who retire, die or transfer to other occupations.

Many more manual welders will be needed for maintenance and repair work in thr growing metal working industries. The number of manual welders in production work is expected to increase in plants manufacturing sheetmetal products, boilers, storage tanks, ships and other structural steel products. The construction industry will need an increasing number of welders as the use of welded steel structure expands. p. 574*

Summary of Related Research

For purposes of this study the writer has found little research directly parallel to the objective of this study.

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*Occupational Outlook Handbook Bureau of Labor Statistics, Bulletin 17.00, U.S. Department of Labor, Washington, D.C., 1973 Edition. 879 pp.

CHAPTER III

SUMMARY OF PRELIMINARY QUESTIONNAIRES

Of the two hundred and eighty (280) preliminary questionnaires sent to industries employing welders, eighty-five (85) responses were returned, with fifty-eight (58) indicating their desire to cooperate further in the study. The tabulation of data provided by the respondents desiring no further involvement in the study is provided in Appendix A, page 54.

Appendix F, page 104,provided an alphabetized list of the cooperating industrial respondents.

Question two asked: "Does your industrial concern employ welders?" There were sixty-seven respondents in the affirmative with eighteen indicating a variety of negative responses. (Appendix A, page 54.

Question three asked: "What percentage of your welders are hired directly upon graduation from vocational welding schools?" Table I, page 59, provides a statistical breakdown by percentages for the reporting industries. Of the reporting industries twenty-nine or 42% do not hire any welders directly out of vocational welding schools. Ten industrial concerns hire 12% of their new welding employees directly from school.

The fourth question: "Do you feel that welders should be more adequately trained by the schools for your welding need?" Fifty-four or 87% indicated yes, four or 6.4% no, with another four or 6.4% undecided.

Question five: "Information from which revised welding curriculum may be developed to reflect your industrial needs can be provided by your allowing a typical production welder and a welding supervisor to fill out a questionnaire describing their duties." Fifty-eight or 70% of the industrial respondents indicated their willingness to respond in greater depth on detailed task analysis questionnaires for a welder and a welding supervisor. The other twenty-five or 30% desired no further cooperation in the study due to the following reasons listed in Appendix A, page 54.

Space was provided for additional comments following question five. The comments were divided as they related to question one through five with general comments last in Appendix A, page 54.

CHAPTER IV

ANALYSIS OF THE WELDERS TASKS AND RELATED SUBJECT MATTER AS REPORTED BY INDUSTRIAL CONCERNS ON THEIR QUESTIONNAIRE REPLIES

Analysis of Welders Questionnaires Sent to Industry

Questionnaires were mailed to the fifty-eight industries desiring to cooperate further with the study plus twenty-nine additional copies to industries either not responding to the original mailing or to industries added to the revised mailing list. From this mailing thirty-five or 40% were returned and usable for computations.

This questionnaire was planned and designed for computer utilization to provide for numerical computation of all data in cooperation with Mr. Gordon Kimbell, data processing instructor, Everett Community College.

This questionnaire consisted of thirty-six questions divided into five sub-divisions: general information, basic education, welding related knowledge requirements, welder related skills and functions, and the manipulative skills required for a production welder. The questions consisted of statements requiring either single or multiple responses given by circling one of three choices: (N) Necessary, (D) Desirable, or (U) Unnecessary, to indicate their importance to the respondent.

The respondents who cooperated in this survey represent both large and small industries hiring from 4 to 600 welders.

No attempt has been made to provide a comparative analysis between the various types of industries represented in this study. All types of metal fabrication industries representative to this geographic area have been included.

The writer designed the questionnaire that it would seek data to reflect the commonalities of welding used in industry with respect to filler materials, base materials, shapes, position welded, and process used. This will assist the welding schools design curriculums reflecting the greatest number of common needs presented by the various types of industries. Due to the great mobility of welders their training ought to be broadly based on data provided by a cross section of the industries employing welders.

The analysis of this questionnaire has been provided question-by-question within each section with the necessary data tabulation provided and referenced.

General Information

The respondents named in question one of the questionnaire have not been provided to secure their identity.

Appendix F, page 104 provides an alphabetized list of all industrial concerns represented in this study requested by question two.

The third question presents the different types of products manufactured by the responding industries and has been provided in Appendix H, page 111.

The entry skill level requested in question four, part (a) varied greatly; 27% made no comment, 37% indicated yes, and 20% expressed no as their response. The experience at time of hiring varied from none to 41 years. Part (b) of question four on certification requirements and type has shown nineteen or 54% required certification with eight or 23% no requirements, while the other eight or 23% gave no comments. The types of weld certification has been provided in Appendix B, Part I, page 62.

Union affiliation for welders was shown to be required by twenty-four or 69%, not required by three or 9%, while the other eight or 23% gave no comment. Table I, page 59, provides a listing of different unions represented and the number of respondents affiliated with each.

Physical examination requirements for employment requested in question six showed eleven or 31% yes, twenty-one or 64% no, while one or 3% gave no comment.

Question seven: "By which of the below-listed welder employment recruiting procedures did you secure your present employment?" The largest percentage of respondents, fourteen or 33%, secured their present job through the union halls, five or 12% from advertisements in local papers, six or 14% through welding schools, while five or 12% were hired directly into industrial production jobs. The other respondents secured their present employment in numerous ways as shown by Appendix B, Part 2, page 62.

Question eight requests: "Highest grade level completed." Responses to this question range from grade seven through fourteen, showing nineteen or 58% of the respondents having high school diplomas, two or 6% having a GED certificate. For complete tabulation, see Appendix B, Part 3, page 63.

Question nine: "Your welding training was provided by:" The responses to this question listed eighteen or 38% for vocational welding schools, seven or 15% on-the-job training, five or 11% community college welding programs, five or 11% high school vocational welding programs, three or 6% apprenticeship programs, while the other respondents were divided as shown by Appendix B, Part 4, page 63.

Question ten: "Was your vocational welding training adequate for your entry level employment needs?" Of the thirty-five responses given twenty-one or 60% yes, twelve or 34% no, while two or 6% were noncommittal. For those whose response was "no," Appendix B, Part 5, page 64, provides a listing of comments relative to the areas of their training deficiencies.

Basic Education

The basic educational section of the welders questionnaire for questions eleven through fifteen has been based on thirty-five reporting industries and provided in tabulated form in Table II on page 68.

The responses given for the welders mathematical problem solving ability in question eleven indicates 54% deemed it was necessary. Of these responses 57% did not believe the teaching of algebra was necessary.

The understanding and application of scientific laws related to mechanics listed in question twelve has been recorded by 48% as desirable. Another 34% has indicated this understanding to be unnecessary. These percentages represent a cross-section of industry whereas the requirements vary greatly within the various industries employing welders.

The welder's human relations aspect of general education was deemed necessary by 51% of the respondents for (a) welder-supervisor and (b) welder-fellow workman, while part (c) welder-society was listed as desirable by 51%.

In the area of welder communications 57% listed report writing unnecessary, 66% listed ability to direct others as desirable, while 94% listed as necessary the ability to receive verbal communications. Welders need to perfect the ability to listen.

The curriculum aspects of economics related to the welder on question fifteen was given four divisions. Part (a) responses on employment were listed by 54% as desirable, (b) 52% of the responses on income and taxes deemed it unnecessary, part (c) listed knowledge of industrial organizations as desirable by 49%, while part (d) on family income, 40% thought it was desirable.

The survey questions on general education requirements for the welder were only intended to provide schools of welding insight into general curriculum areas of concern.

Welding Related Knowledge Requirements

This questionnaire section encompasses questions sixteen through thirty-one dealing with the related knowledge aspects of the welders training. The percentages provided in this section are based on thirty-five industrial welder respondents. A detailed accounting of the survey information is provided in Table II on page 68.

The ability to interpret blueprints, shop drawings and weld symbols was thought necessary by 69% of the respondents to question sixteen. The ability to make simple pictorial drawings was thought necessary by 34% and desirable by 46% on question seventeen. In questions eighteen and nineteen, the ability to use and interpret hydraulic, pneumatic and electrical drawings was thought unnecessary by 51%, but desirable by 49%.

The knowledge of weld characteristics sought by question twenty has been given sub-divisions (a) through (g). Division (a) low and medium carbon steel was thought necessary by 71%, (b) low alloy steels necessary by 71%, while (c) high alloy steels necessary by 57%. Part (d) aluminum alloys was thought necessary by 46%, (e) magnesium alloys necessary by 31%, with (f) titanium alloys necessary by only 29%. Division (g) of question twenty was supplied by the respondents who listed cast iron, copper and nickel and their alloys.

The heat treating of metals posed by the four subdivisions of question twenty-one has shown: (a) annealing, desirable by 35%, (b) normalizing desirable by 37%, (c) hardening desirable by 49%, with part (d) tempering or drawing shown desirable by 52% of the respondents.

Question twenty-two on the understanding of electricity as related to: (a) AC-DC welding power source was listed as 51% desirable and (b) motor generator welding power source with 57% desirable, and (c) alternating current power source with a 63% desirable listing.

The welding characteristics of metals referred to in question twenty-three showed 48% of the respondents listed necessary, while another 43% indicated desirable.

Question twenty-four on weld structure design understanding, listed 40% necessary and 40% desirable.

An understanding of the welding characteristics of basic types of joints in question twenty-five was thought to be necessary by 63% of the respondents.

In question twenty-six 57% indicated the necessity for welders to understand the effect of welding on heat treated metals.

The welders understanding of welding terms and processes in question twenty-seven showed 69% deem it as necessary.

In question twenty-eight 80% of the respondents believed the welder should understand the characteristics of a quality weld.

Question thirty-one, part (a) which related to the possibilities and limitations of the various industrial metal cutting processes, 40% indicated necessary, part (b) 43% indicated a desirable response for the welders understanding of codes and specifications, part (c) 74% indicated necessary for the welders understanding of weld sequences as related to distortion, part (d) 80% indicated necessary to the welders awareness to hazardous fumes and gases when welding on certain metals.

Welders Related Skills and Functions

This section of the questionnaire has concerned itself with welding related equipment, skills, and functions the welder may or may not be concerned with. Question thirty-two on equipment operation has sub-divisions (a) through (n) and Table IV has provided a detailed account.

The equipment with responses of over 40% necessary included grinders and sanders, efficient use of hand tools, jigs and fixtures, and the taps, dies and reamers. Those pieces of equipment thought unnecessary by over 40% of the respondents included the press brake, punch, squaring shear, brake and nibbler, lathe, shaper, mill, hydraulic lifts, and pneumatic systems.

Question thirty-three with sub-divisions (a) through (o) has been shown in Table II on page 68 . This question concerns itself with the welders related functions. Those functions deemed necessary by over 40% response included: arc gouging, read and interpret prints for job, fit up for job, select materials for job, select electrodes for job, and position for welding. Likewise those functions thought unnecessary by over 40% included: repair weld machines, heat treating of metals and metal spraying and finishing.

Respondent provided remarks for additions to question thirty-two and thirty-three included: (1) cranes and rigging, (2) rigging and crane signals, and (3) hoist safety and use.

Manipulative Skills for a Production Welder

This questionnaire section has included questions 34, 35, and 36. Each questions has included multiple parts which have been shown in Table II on page 68.

Question thirty-four has related itself to the weld processes, type of joints and their weld application in the various positions. Reference here has included processes, positions, and types of beads with their greatest percentage of usage. Of the four welding processes oxy-acetylene was shown to be the least used. This process was shown by 52% of the respondents to have its greatest usage on the butt joint.

The arc welding process was shown to have over a 70% usage in all positions, all types of joints, with stringer beads. The weave motion was most used on the butt joint.

The "TIG" process was used by over 50% of the respondents in all positions and joints with stringer beads.

The "MIG" process was used by over 50% of the respondents with stringer beads on all joint types in the flat, horizontal and vertical positions. The weave motion on butt joints was shown to have a 55% usage. A detailed inspection of Table II will provide the reader with a complete account of the data for this question. Respondents' remarks for this question are found in Appendix C, Part 7b, page 84.

Question thirty-five presentation has been provided by Table II, page 68, with emphasis given points showing the greatest or least percentage of use. Twenty-four respondents completed this questionnaire section while eleven respondents left it blank because their production lines used exclusively the MIG and TIG processes or question was not applicable to their industry.

Section (a) of question thirty-five shows stringer beads were used most extensively with the largest percentages on the butt joint. The weave motion has its greatest usage on the butt joint.

Section (b) of question thirty-five has shown electrode types E6010, E6011, E7018, and #7024 to have had the greatest usage on all types of joints. The electrode sizes with greatest usage was shown to be the 1/8 inch diameter E6010, E6011, and E7018, while the 5/32 inch diameter E7024 and E7028 were most used.

Question thirty-six was concerned with industrial usage of metals relative to type, shape and thickness used. Section (a) sheetmetal was found to have its largest percentage of use in the butt joint with the 3/32 inch electrode.

For 3/16 to 1/4 inch thick materials the largest percentage of use was on fillet and corner joints using 1/8 inch electrodes. For the 5/16 to 3/8 inch materials the largest percentage of usage occurred on butt, lapp, and fillet joints using 1/8 or 5/32 inch diameter electrodes. Steel 1/2 inch or more in thickness was least used with the edge joint preparation.

Section (b) of question thirty-six was concerned with the metal shapes used by industry as related to the joint type and electrode sizes used. For the butt joint, pipe welded with 1/8 inch electrodes showed the greatest usage. The welding of the various metal shapes was quite evenly divided between the use of 3/32, 1/8, and 5/32 inch electrodes. The pattern of electrode use for each of the other joints was shown to be quite similar, except for the edge joint.

Part (c) of question thirty-six on type of materials used has shown mild steel most used followed by low alloy steel, high alloy steel, aluminum, and titanium. The metals listed here are quite incomplete, but does give the welder an indication of those metal shapes and types most widely used in industry.

CHAPTER V

ANALYSIS OF THE WELDERS' TASKS AND RELATED SUBJECT MATTER AS REPORTED BY WELDING SUPERVISORS AND A NATIONALLY SELECTED CONTROL GROUP ON THEIR QUESTIONNAIRE RETURNS

Analysis of Questionnaires Returned by Welding Supervisors And Nationally Selected Control Group

The materials provided within this chapter have been arranged in parallel order to provide the reader with comparative data tabulations for the welding supervisors and the nationally selected control group. No attempt has been made to provide the reader with a comparative analysis between the welders and welding supervisors of region or nation.

The empirical data requirements for this part of the study were provided by mailing ninety-four questionnaires, which included fifty-eight to industrial concerns desiring further cooperation in the study plus another thirty-six to industries added to the revised mailing list. Forty-one or 43.6% usable questionnaires were returned from the ninety-four mailed to welding supervisors living within the study's geographic boundaries. To provide greater validity for this study, a nationally selected control group has been provided by sending twenty-two questionnaires to American Welding Society Regional Presidents throughout the United States. From this mailing, twelve or 54.5% usable returned questionnaires were selected as a control group.

The planning of this questionnaire provided for computer processing of numerical data computations in cooperation with Everett Community College data processing instructor, Mr. Gordon Kimball.

The thirty-eight questions of the questionnaire were given four subdivisions: general information, basic education, welding related knowledge requirements, and future welding trends. The reporting of data encompassed within this study shall be provided with a comparative analysis question by question for each section with the necessary tabulations provided and referenced in Appendix C and Table III. The national and regional numerical data reported by the respondents has represented the welding supervision of all types of both large and small metal fabrication industries.

General Information

The general information section of the welders' training needs and requirements has been reported on page 91, of Table III, with the comments supplies by Appendix C, page 101 through 102.

The respondents' names requested by question one have been provided in Appendix E, page 103 for the national control group, with no listing provided for the welding supervisors to protect their identity.

The names of the industrial concerns represented by the respondents have been provided jointly for welders and welding supervisors within the Appendix D listing on page 101.

In question three, the types of products manufactured have been provided by Part 2 and 3 of Appendix F on page 106.

Question four on employment skill level requirements has two subdivisions. Part (a) on experience requirements has shown twenty-eight or 64% reporting yes for welding supervisors, and four or 33% yes for the control group. The industrial comments relative to this part of the question have been provided by Appendix C, Part 1a and 1b. Part (b) of question four on certification requirements has indicated fifteen or 37% no by the welding supervisors with eight or 66% no for the control group. Appendix C, Part 2a and 2b, on page 75, has provided all comments relative to this question.

Question five on union affiliation has shown thirty-one or 75.6% yes for welding supervisors and eight or 72% yes for the control group. The unions represented have been shown in Parts 3a and 3b of Appendix C, page 76.

The number of welders reported by question six has listed 3,386 employed by the industries represented by the welding supervisors and 5,292 employed by the control group.

Question seven responses for physical examination requirements was listed yes by nineteen or 46% of the welding supervisors, and by six or 50% yes for the control group. Fifty-four percent of the welding supervisors reported they have no physical examination requirements.

Question eight: "By which of the following methods are welders recruited for employment?" Table III, page 91, has provided a complete listing of methods used and their percentages. For the welding supervisors twenty-one or 61% listed recruitment through union halls greatest, followed by twenty or 49% having used welding schools. The respondents have listed more than one way by which welders were recruited; therefore, the reported percentages may have appeared to be inaccurate. For the national control group, welder recruitment procedures has listed six or 50% each for State Employment Service and advertisement in local papers.

Question nine: "Do you have any general education grade level requirements?" Thirty-two or 80% of the welding supervisors and seven or 58% of the control group have no general education requirements. Reference Table III, page 91.

Question ten: "Your welders were trained principally by:" The vocational welding schools were listed as the number one training method by twenty-three or 56% of the welding supervisors and by eight or 66% of the control group. "On-the-job-training" was the second most often listed training method. Table III, page 91, has provided additional data.

Question eleven: "Was the vocational welding training adequate for your welders' entry level employment needs?" The opinions of the respondents to this question have indicated a negative response twenty-one or 51% for the welding supervisors and seven or 58% for the control group. In response to this question the areas of deficiency provided by the industrial respondents have been listed in Appendix C, Part 4a and 4b, page 77.

Question twelve: "Please list within your industrial concern the job levels of personnel who are employed in welder occupations by skill level." The responses to this question have varied greatly throughout the various industries employing welders. These responses have been provided in Appendix C, Part 5a and 5b, for the readers perusal. Four suggested occupational ladder groupings with their respective rate of occurrence have been provided for the welding supervisors and the control group on page 91, of Table III.

Basic Education

The Basic Education Section has been supported by parallel columns showing both the regional and national percentage of responses in Table III, page 91.

Question thirteen on mathematical problem solving ability has indicated a 51% desirable response by regional supervisors and a 45% desirable response by the control group.

Question fourteen on the basic understanding and application of scientific laws as related to mechanics has shown a 53% and 36% desirable response respectively for regional and national welding supervisors.

Question fifteen on human relations has subdivision (a) through (c). Part (a) welder-supervisor relations has indicated a 53% necessary response by the welding supervisors and a 63% desirable response by the control group. Part (b) welder-peer relations has provided a 48%, 73% desirable response respectively for the regional and national responses. Part (c) on welder-society relations the respondents have indicated a 37%, 72% desirable response respectively for region and nation.

Question sixteen on communication has three subdivisions. Part (a) on welders ability to write reports was thought unnecessary by 41% of the welding supervisors. The control group indicated a 54% desirable response. Part (b) of the question on the verbal direction of others a 54%, 63% desirable response was provided by regional and national respondents. Part (c) of the question on the receiving of verbal communications was thought necessary by 83% and 91% respectively of regional and national respondents.

Question seventeen on economics as related to the various aspects of the welders life have been provided by parts (a) through (d). Part (a) on employment was thought desirable by 39%, 63% respectively of the regional and national respondents. Part (b) on income and taxes was thought unnecessary by 53%, 45% respectively for the regional and national respondents. Part (c) of question on economics as related to industrial organizations was thought to be unnecessary respectively by 41%, 45% of the regional and national respondents. Part (d) on family finance management was thought to be desirable for welders by 41%, 54% respectively by the regional and national respondents.

Welding Related Knowledge Requirements

Questions eighteen through thirty-three have requested information concerning the welder's related knowledge requirements for industrial employment.

Question eighteen on the welder's ability to interpret blueprints, shop drawings, and welding symbols was thought to be necessary by 60% and 64% respectively by regional and national respondents.

Question nineteen dealing with the welder's ability to make simple pictorial and three-view drawings was thought to be desirable by 66% of the responding welding supervisors, while 46% of the national respondents thought this ability was necessary.

Question twenty and twenty-one relating to the welder's ability to use drawings for electrical welding equipment and hydraulic and pneumatic systems was thought to be unnecessary by over 66% of the welding supervisors and desirable by over 45.5% of the national control group.

Question twenty-two concerning the welding characteristics of commonly used metals has subdivisions (a) through (g). Subdivision (a) on knowledge requirements for low and medium carbon steel was thought necessary by 78% and 82% respectively of the regional and national welding supervisor respondents. Subdivision (b) on low alloy steels was thought to be necessary by 61% and 64% respectively of both regional and national respondents. Subdivision (c) on high alloy steels was thought to be necessary by 51% and 55% respectively of regional and national respondents. Subdivision (d) for aluminum alloys was thought necessary by 42% and 36% respectively for regional and national respondents. Subdivision (e) for magnesium alloys was thought unnecessary by 37% of the welding supervisors, while 50% of the national control group thought it desirable knowledge for welders. Subdivision (f) on titanium was listed as unnecessary by 39% of the welding supervisors while 55% of the national control group thought this was desirable knowledge for welders. The request for additional metals in subdivision (g) of question twenty-two have been listed in Appendix C, Part 6a and 6b on page 83.

Question twenty-three on the heat treating of metals has four subdivisions. Division (a) on annealing was thought desirable by 39% and 63% respectively of regional and national industrial respondents. Division (b) on normalizing was listed both necessary and unnecessary by 39% of the regional welding respondents. A desirable response was provided by 63% of the national respondents. Division (c) on hardening of metals was listed as unnecessary by 42% of regional respondents while a 55% desirable response was provided by the national respondents. Division (d) on tempering or drawing was listed by 39% of regional respondents as unnecessary and as desirable by 55% of the national respondents.

Question twenty-five on the understanding of electricity as related to welding equipment has three subdivisions: AC-DC rectifier, motor generator, and alternating current power sources. Of those responding over 51% listed this knowledge as desirable for the welder by both the regional and national respondents.

Question twenty-five: "Characteristics of metals as related to weldability, melting point, tensile strength, brittleness, yield point, expansion, and contraction." This knowledge was thought to be desirable by 46%, and 73% respectively of the regional and national respondents.

Question twenty-six has listed a 44%, 45% respective desirable response for the welder's understanding of design for welded structure by regional and national respondents.

Question twenty-seven regarding the welder's understanding of basic type joints and their understanding when welded was thought to have been necessary by 63%, 45% respectively by the regional and national respondents.

Question twenty-eight on welding and it's affects on heat treated metals was listed as necessary knowledge by 47%, 45% respectively for welders by the regional and national respondents.

Question twenty-nine on the understanding of terms and processes for welding was thought to have been necessary by 78%, 73% respectively by the regional and national respondents.

Question thirty on the knowledge of a quality weld was thought to have been necessary by 90% or more of both regional and national respondents.

Question thirty-one on the understanding of weld testing and inspection was listed as unnecessary by 39% of regional respondents, while 55% of the national respondents thought this knowledge was desirable for the welder.

Question thirty-two on the understanding of welding related cost factors was listed as unnecessary by 20%, 18% respectively for regional and national respondents.

Question thirty-three on production related factors has four subdivisions. Division (a) "Understanding of the possibilities and limitations of various cutting processes with respect to metals and their alloys used in industry." A 51%, 84% respective desirable response was provided by regional and national respondents. Division (b) "Understanding of codes and specifications related to welding," has been given a respective 39%, 55% desirable response by the regional and national respondents. Division (c) on the understanding of welding sequences as related to distortion was given a 61%, 55% necessary respective response by the regional and national respondents. Division (d) on the welder's awareness to hazardous fumes and gases when welding on certain materials was given a respective 75%, 82% necessary response by regional and national respondents.

Future Welding Trends

This welding supervisors questionnaire section has sought information to assist the vocational welding schools to keep abreast of change. For the questions on future welding trends the regional and national respondents have provided directional emphasis for welding curriculum development. The value of these responses are restricted by the personal limitations of each respondent.

Question thirty-four, "Forecasts indicate great numbers of new welders shall be needed by industry. Where may these people best be trained?" has five subdivisions with the quest for industrial suggestions. Subdivision (1) on high school vocational classes was provided with a 27% response by regional and national respondents. Subdivision (2) on private welding schools was provided with a respective 27%, 64% response by regional and national respondents.

Subdivision (3) on post high school vocational welding classes was provided with a 39%, 46% respective response by regional and national respondents. Subdivision (4) "A combination of the three above methods plus industry provide additional on-the-job training relative to their particular needs," has been given an 83%, 100% respective response by regional and national industrial respondents. Subdivision (5) on private industry training their own people was given a 27%, 46% respective response by regional and national respondents. Further industrial suggestions were listed and have been provided in Appendix C, Part 9b, page 85.

Question thirty-five on weld process increase or decrease has been subdivided by the individual process. Subdivision (a) on oxy-acetylene welding was thought to be decreasing by 58.6% of the regional welding supervisors and 75% of the national respondents. Subdivision (b) on metallic arc was thought to be increasing by a 61%, 72% respective response for the regional and national respondents. Subdivision (c) on gas metal arc welding (GMAW) solid core wire was thought to be increasing by 80.5%, 100% respective response by regional and national respondents. Subdivision (d) on gas metal arc welding with (inner shield) wire was given approximately the same response. Subdivision (e) on gas tungsten arc welding (GTAW) was thought to be increasing by 90%, 64% respective response for regional and national respondents. Subdivision (f) on plasma arc welding was provided with a 80.5%, 72% respective response by regional and national respondents. Subdivision (g) on ultrasonic welding was thought to be increasing by over 70% of all respondents. The complete tabulation for question thirty-five has been provided by Table III, page 91, with the related remarks relative to question in Appendix C, Part 10b, page 87.

Question thirty-six: "Should welding schools be involved with welder certification?" Sixty-one percent of the regional welding supervisors indicated yes while 73% of the national group indicated a negative response.

Question thirty-seven: "Should welding schools be involved with the teaching of welding code requirements?" To this question a 90%, 100% respective positive response was provided by regional and national respondents. The appropriate relative remarks are provided in Appendix C, Part 12a, page 91.

Question thirty-eight: "Should welding schools enter into more cooperative educational programs with industry employing welders?" To this question an 80% positive response was provided by all respondents. The requested responses relative to how this cooperative approach could be accomplished have been provided by Appendix C, Part 13a and 13b, on page 92.

CHAPTER VI

SUMMARY OF THE ANALYTICAL STUDY TOGETHER WITH CONCLUSIONS AND RECOMMENDATIONS

Summary

General Information. The information needed for this study has been provided by a two stage questionnaire. The preliminary questionnaire consisted of an introductory letter followed by five questions which were mailed to two hundred and eighty potential employers of welders within Washington State, Portland, Oregon, and Vancouver, British Columbia. This survey questionnaire sought answers concerning: (1) industrial cooperation in an in-depth study, (2) do you hire welders, (3) percentage of welders hired directly from vocational welding schools, (4) were these welders adequately trained for your welding needs, and (5) would you cooperate to provide information from which revised welding curriculums may be developed.

From eighty-five responding industries to the preliminary questionnaire, fifty-eight desired further cooperation in the study. Question two has indicated sixty-seven of the responding industries hired welders. In question three there were twenty-nine industries not hiring any welders directly out of vocational welding schools. There were fifty-four of the reporting industries who felt welders should be more adequately trained. From the responses to question five, fifty-eight or 70% were willing to fill out an in-depth questionnaire to provide factual data from which welding curriculums may be revised. The industrial remarks relative to these questions have been provided by Appendix A, Parts 1, 2, and 3, on pages 54 through 56.

The second stage of this study has consisted of three parts; a questionnaire for the production welder, a questionnaire for regional (survey area) welding supervisors, and a questionnaire for national located welding supervisors.

The welders questionnaire was mailed to eighty-seven industrial concerns; fifty-eight of which desired further cooperation in the study plus twenty-nine which were mailed directly on a revised mailing list. From this group thirty-five usable returned questionnaires have been selected for data computations.

The questionnaire for welding supervisors was mailed to ninety-four regional industries; fifty-eight desiring further cooperation in the study plus thirty-six added to a revised mailing list from which forty-one usable returned questionnaires were selected for data computations. For the national control group twenty-two regional American Welding Society Presidents were mailed this questionnaire from which twelve usable returned questionnaires were selected for usage within the study.

The welders questionnaire consisted of thirty-six questions with five subdivisions: general information, basic education, welding related knowledge requirements, welders related skills and functions, and the manipulative skills required for a production welder.

The welding supervisors questionnaire consisted of thirty-eight questions with four subdivisions: general information, basic education, welding related knowledge requirements, and future welding trends. Both questionnaires were designed to facilitate computer usage for the rendering of the data. The industrial remarks and detailed data computations have been provided within Appendix A, B, and C with their Parts and Tables I, II, and III, pages 58 through 91.

Questionnaire Analysis. The questionnaires returned represent the industrial concerns listed in Appendices D and E, and have provided the data for this analysis.

The preliminary questionnaire data computations and industrial comments have been provided by Appendix A and Table I. The welders comments and data computations have been provided by Appendix B with its parts and Table II. For the welding supervisors of region and nation, the data and industrial comments have been provided by Appendix C with its parts and Table III. Appendix F, Part I, 2, and 3, provide listings of products manufactured by all respondents.

The summation of data provided by the welder's questionnaires have shown 42% of the welders surveyed had no experience requirements, though 54% indicated some form of welder certification prior to employment. For the welding supervisors, 64% of regional and 33% of national control group had entry level experience requirements, while welder certification requirements were listed as necessary for 29% of regional and 66% of national respondents.

Union affiliation requirements were mandatory by approximately 70% of all respondents. The unions represented are listed in Appendix B, Part 2, page 62, and Appendix C, Part 3a and 3b, page 76.

The surveyed welding supervisors have indicated 8,678 employed welders were represented within their jurisdiction. No physical examination requirements were reported by 64% of the welders, while 46% or greater of regional and national welding supervisors have indicated the necessity for a pre-employment physical examination.

The regional recruitment of welders was shown to be greatest through union hall dispatching, while nationally, the state employment service and advertisements in local papers had the largest percentage of use.

Of the welders surveyed, 58% had their high school displomas. Over 58% of both regional and national industrial respondents had no basic educational requirements.

For the welders surveyed, 38% were trained by vocational welding schools. The welding supervisors have indicated the largest percentages were trained by vocational welding schools, followed by "on-the-job training."

The adequacy of welders' training has shown a 60% positive response by the surveyed welders, and a negative response by 51% or more by the regional and national welding supervisors.

Responses to question twelve on the occupational ladder varied greatly, and have been provided by Appendix C, Part 4a and 4b, page 78 . The writer has assembled a suggested occupational ladder encompassing four general types from data supplied by the respondents with the number of response entries included for each in Table III, page 94.

Basic Education. Analysis of basic education has indicated that mathematics through algebra was desirable knowledge for welders by 45% (or more) of the three groups surveyed.

An understanding of scientific laws as related to mechanics was thought desirable by over 48% of the welders, regional welding supervisors, but only 37% of the national control group.

The question on human relations for the welder and his supervisor, fellow workman, and society was thought necessary or desirable by over 50% of the three groups surveyed.

The ability to receive verbal communications was thought necessary by over 83% of all respondents.

The knowledge of welder related economics was given mixed consideration from desirable to unnecessary.

Welding Related Knowledge Requirements. The ability to interpret blueprints, shop drawings, and welding symbols was thought necessary by over 60% of all respondents. The ability to interpret and use drawings related to hydraulics, pneumatics, and electricity was thought necessary by less than 10% of all respondents.

The knowledge of weld characteristics of low and medium carbon steel and low and high alloy steel was thought necessary by over 51% of all respondents. For aluminum this knowledge was felt necessary by over 36%, while magnesium and titanium dropped to less than 31%.

For the heat treating of metals, the respondents listed this knowledge as necessary by less than 39% of all respondents with normalizing receiving the highest percentage rating.

The understanding of electricity as related to the welding machines was thought desirable information for the welder by over 51% of all respondents.

The metallurgical characteristics of metals as related to weldability, melting point, etc., was listed as necessary by over 42% of the welders and regional welding supervisors, while by only 27% of the control group.

The understanding of design for welded structure was listed as desirable knowledge for welders by 40 percent or more of all surveyed respondents.

The understanding of welded joint characteristics was thought to be necessary by 40% or more of all respondents surveyed.

Welding and its effect on heat treated metals was listed as necessary by 45% or more of all respondents surveyed.

The understanding of welding terms and processes was listed as necessary by 69 percent or more of all respondents.

The understanding of the characteristics of a quality weld was thought necessary by 80% or more of all respondents.

An understanding of testing and inspection was listed as necessary by 31% of the welders, and by 39 percent or more of regional and national welding supervisors.

For the understanding of cost related factors, 29% of all surveyed respondents reported this knowledge as unnecessary.

The understanding of metal shaping processes and their limitations as related to the welder was considered necessary by 40% of the welders as compared to 27% or less of the regional and national welding supervisors surveyed.

The understanding of welding codes and specifications was considered necessary by 34% or less of all respondents.

Distortion as related to welding sequences was considered necessary knowledge for welders by 55% or more of all the respondents.

Over 75% of all respondents considered the welders' knowledge of hazardous fumes as necessary.

Welding Related Skills and Functions. The welders considered their ability to use grinders and sanders, small hand tooks, jigs and fixtures, and taps, dies, and reamers most essential. The least essential equipment operation skills included use of the punch, lathe, shaper, and mills, and pneumatic systems.

Welding related functions considered most essential included arc gauging, read prints for job, fit up for job, select materials and electrodes for job, and position for welding. The items considered least essential included: repair welding machines and metal spraying and finishing.

Manipulative Skills for a Production Welder. The skills listed with the highest percentage included: arc welding the butt joint, lap and fillet joint using stringer beads. The least used process was oxy-acetylene in the overhead position using the weave motion.

The welding electrodes most used included E6011, E7018, and E7024 with 1/8, 5/32, and 3/16 inch diameter running stringer beads. The least used included the weave motion, the eduge joint, 3/16 inch diameter electrode, and the E6012, E6013, and E7028 electrode types.

The metal thickness having recorded the highest percentage of use included the 3/16" to 3/8" thickness with 1/8" and 5/32" electrodes. The metal shapes used are evenly divided, but show their highest percentage of use with the butt and fillet joints.

The type of metal most used included mild and low alloy steel. The use of high alloy steel and aluminum were indicated to be equal except on corner, lap, and edge joints.

Future Welding Trends. To meet the anticipated need for large numbers of new welders, the regional and national supervisors have indicated by 83% and 100% respectively that their training might be best anticipated by a combination of vocational welding classes in high schools, private schools, and post high schools with special training provided by industry.

For the welding processes, over 58% of all respondents have indicated a decline for oxy-acetylene welding, while shielded metal arc (SMAW), gas metal arc (GMAW), flux core arc (FCAW), gas tungsten arc (GTAW), plasma arc (PAW), and ultrasonic (USA), have indicated an increase in usage by 61% or more of all respondents.

The welding schools involvement with certification was thought necessary by 61% of regional and unnecessary by 27% of national welding supervisors.

The teaching of welding code requirements was thought necessary by 90% or more of all industrial respondents.

Eighty percent or more of the industrial respondents felt the welding schools should enter into some form of cooperative educational programs with industry. Appendix C provides the industrial remarks for the previous discussed points of concern.

COMPARATIVE ANALYSIS WITH BACON'S 1964 THESIS DATA

General Information. The materials provided in Table 4, page 120 question (10) through (40) showing percentages from industry and the respondents have been taken from Bacon's 1964 Thesis at the University of Washington. This data was provided by thirty-eight industrial respondents within the geographic boundaries of Washington and Oregon States. The national control group has included fourteen respondents representing three levels of government, governmental agencies, professional societies, labor, technical institutes, higher education and the various types of industries. These respondents represented all types of industry both large and small. For the readers' complete analysis of this data, the thesis has been made available through the University of Washington Library, Seattle, Washington.

This analysis has provided only the largest comparable percentages.

Analysis 1964-1974 Data. Basic education requirements for welders has indicated their need to receive verbal communication in the 1974 study while ability to read was greatest in the 1964 study. The questions have varied but the responses have indicated the importance of communications.

The responses of both studies has shown a high desirable response for algebra and the 1964 study has shown a high desirable response for algebra and trigonometry.

The responses from both studies has shown the desirability of teaching metallurgy and welding related characteristics.

Welding and related knowledge requirements from the 1964 study has indicated the importance of industrial safety, blueprint development and reading, welding theory, welding application and the welding and metal shaping processes. Though the questions have varied, the importance of each has been shown by the 1974 study.

All groups of respondents from both studies have indicated the importance of welder certification skills, practices of safety in welding and shaping of metals, selection of electrodes and materials for job and the welding on various types and shapes of metal. Should the reader have need of a more detailed inspection of data, contact University of Washington Library, Seattle, Washington 98195.

CONCLUSIONS

1. Large percentages of industry do not hire any welders directly from vocational welding schools.

2. Many respondents felt the schools should do a better job of training welders for their industrial needs.

3. The need exists for greater industry-welding school cooperation for the training of welders. The anticipated need for large numbers of new welders could best be met by cooperative training programs with industry providing the final training aspects peculiar to their respective needs.

4. The largest percent of welders were trained by vocational welding schools.

5. Welding schools should teach welding related certification requirements for the welder but should not become certification stations.

6. The trainee welder should be taught general information relative to welding code requirements.

7. Welders need to know how to make and use welding drawings and symbols.

8. Basic education involving mathematics, scientific laws of mechanics, human relations, communications, and economics related to employment and home was thought to be desirable knowledge for all welders.

9. Welders need to know and understand the metallurgical characteristics of common metals and the effects of welding on them.

10. Welders were expected to know and understand the characteristics of a quality weld, welding sequences, welding processes, testing and inspection procedures, and weld-joint design and their welding characteristics.

11. Welders should have a working knowledge of most welding related equipment operation and specifically of grinders, sanders, hand tools, jigs-fixtures, and taps, dies and reamers.

12. Welders should be able to arc gouge, fit up and position for job, and select electrodes and materials for the job.

13. Welders should possess certifiable skills on common metals, types of welds and joints, filler metals, and processes with some experience in the unusual as related to out of position, poor fit up, etc.

14. The occupational ladder for industrial welders varies greatly throughout industry or does not exist.

15. Oxy-acetylene welding should no longer be considered an industrial welding process.

16. Welding related aspects of safety should be known and understood by all welders.

17. The majority of welders are high school graduates.

18. Of the various regional industrial welder recruitment procedures, the largest percentage were recruited through the union halls.

19. Most welders are required to be affiliated with one of the several unions having jurisdiction of welders.

20. The majority of industry employing welders have no physical examination requirements.

RECOMMENDATIONS

1. Welding schools should survey industrial hiring practices within their respective areas to determine the acceptability of their graduates.

2. Due to the number of respondents indicating deficiencies in the training of welders, it behooves all schools teaching vocational welding students to review their curriculums relative to industrial needs.

3. Industry, unions and all types of vocational welding schools should seek greater cooperation to enable cooperative training programs for students, instructor up-dating, on-the-job training, yearly industrial field trips for students, industrial representatives speak to welding classes on campus, and with more sharing (loaning) of equipment and materials for specific facets of training.

4. Welders are not recognized as a trade in their own right, but if they were this might facilitate: (1) one organization for collective bargaining, (2) a more clearly defined occupational ladder, (3) more meaningful welding education programs all the way from the apprentice or beginning welder to the welding engineer, (4) and, for welder recruitment and hiring practices.

5. Due to the low percentage of welders hired directly from and trained by community college welding programs, additional diagnostic research ought to be conducted and corrections implemented.

6. An industry-wide occupational ladder ought to be developed involving the combined cooperation of industry, unions and all regulatory agencies, including governmental.

7. Welding education after basic training has been completed should be industry-school cooperative training experiences with student spending a part of each day or week on an industrial job.

8. Washington State ought to develop an orderly means by which highly qualified, experienced, certified welders can receive educational experiences including cadeting under the direction of qualified instructors. This would provide a recognized source of welding instructors and would not be the "thrown-to-the-wolves" experience most receive in our present system.

9. Welder trainees must be taught the characteristics of a quality weld, processes of testing and inspection, and the effect of welding on metals and joints.

10. Welding schools and industry must cooperate to provide a continuous program of safety education including the responsibilities of state and federal agencies, industry and welder.

11. A comparable study to this needs to be conducted approximately every ten years with a surveillance of trends to phase in or out the changing welding processes.

BIBLIOGRAPHY

1. Altman, James W., Director. "Research on General Vocational Capabilities," American Institute of Research, Pittsburg, Pennsylvania, 1966. 151 pp.

2. Bacon, Charles L. "Development and Evaluation of a Resource Unit in Welding and Metallurgy for the Welding Technician Program." Unpublished Master's Thesis, University of Washington, Seattle, 1964. 146 pp.

3. Blodget, Omer W. Design of Welded Structures. Cleveland, Ohio: James F. Lincoln Arc Welding Foundation, 1966. 8-2-2 pp.

4. Borcher, Sidney D. and William H. Melching. Procedures for Constructing and Using Task Inventories, Center for Vocational and Technical Education. The Ohio State University, Columbus, Ohio. Prepared by grant for Washington, D.C., U.S. Department of Health, Education and Welfare, 1973. 56 pp.

5. Borgas, Warran. Letter to Charles F. Bacon. February 19, 1974.

6. Department of Planning and Development. Directory of Oregon Manufactures. Portland, Oregon: 1974.

7. Department of Planning and Development. Directory of Washington State Manufacturers. Portland, Oregon, 1974.

8. Mitchell, J.W., Manager, Welding Development Department, Ford Motor Company, Letter to Charles F. Bacon, February 7, 1974.

9. Occupational Outlook Handbook. Bureau of Labor Statistics Bulletin 17.00, U.S. Department of Labor, Washington, D.C. 1973 Edition. 879 pp.

10. Stemmer, Roland Clark. "A Study of the Whole Part (Multi-Position) Approach as Compared to the Traditional (Single-Position) Approach in the Development of Arc Welding Skills." Unpublished Doctor's Thesis, Oregon State University, Corvallis, Oregon, 1973. 82 pp.

11. Task Analysis Inventories. Washington, D.C. U.S. Department of Labor, Manpower Administration, 1973. 201 pp.

12. Welding Handbook - Section 2 - Welding Processes. New York: American Welding Society, 1969.

13. Welding Instructors Association of Washington, Ken Miller, Chairman. Summary Report of Puget Sound Welding Survey. Funded by Program Planning and Research, Coordinating Council of Occupational Education, Olympia, Washington, 1973. 3 pp.

Appendix A, Part I

COMMENTS MADE BY RESPONDENTS ON PRELIMINARY LETTER OF INQUIRY

Report of comments from inudstrial concerns not wishing further participation in the study.

1. "I will allow a welder supervisor and production welder to fill out your questionnaire provided you mail me the form and allow us to schedule time for completion of the questionnaire. I will not allow investigative teams in the foundry for the purpose of interviewing, product sampling and etc."

2. "We do not employ production welders. As a part of a maintenance mechanic's duties he is expected to weld. We train our people in these skills."

3. "Good welders we could use now."

4. "Ours is a maintenance responsibility with light fabrication only."

5. "Sorry, but I have no welders working for me and have no experience in that area."

6. "Welding only occasionally involved in our maintenance work, never in production."

7. "Our needs in welding are very limited and confined to rather ordinary jobs that can be performed by a worker with only basics in training."

8. "We are only a two-man shop (father and son). Father was trained at Curtis-Wright Tech. before World War II. Son was taught by father in all aspects of welding and fabrication."

9. "Only welding done by our maintenance people is on repair and installation of new equipment. Where aluminum welding is required, we have it done by an outside welding firm."

10. "Sorry we do not employ welders."

11. "No factories in this state -- clerical and service personnel only."

12. "Not operating and the future is not known."

13. "We do not use "Production Welders" in our business. Repairing smaller vessels requires welders with varied abilities."

14. "The company is involved with Mt. Hood Community College on a three-year program with each new hire."

15. "Sorry, we do not do any production welding at our plant."

16. "I am a sales representative for Weld Tooling Corporation and do not feel qualified to fill out the questionnaire. Good luck with the endeavor."

Appendix A, Part II

Report of comments from those desiring further participation in the study.

Question Three

1. "Do vocational schools have a placement service?"

2. "We have to hire through the union and we have to take what they send. Sometimes we have to go through two or three men to get what we want."

3. "Our welders receive on-the-job training and are promoted from within our own employee group."

4. "By agreement with our employee's association, all jobs which require skills are filled on the basis of seniority by employees who desire to advance. Welders, for example, start as welder learners with on-the-job training and advance as indicated by the attached job classification."

Question Four

5. "Most of the welders fresh out of welding school cannot be put on production welding. They generally have no understanding of welding sequence and odd shaped parts or out-of-position welding throws them."

6. "We find that many young fellow are told at trade schools 'how good they are,' which is fine, however, when they are hired and find out they are not productive, it is quite a setback - more emphasis should be placed on the fact that if they can't produce, the employer can't afford them."

7. "Try teaching your welders to make each move count. Most of them make too many wasted movements!"

8. "I feel that welders should have a working knowledge of other phases of iron work, particularly the reading and working from detail drawings, and to include fit-up of raw materials prior to welding, production methods, etc.

9. "Welders should be trained more in set-up work and blue print reading. Ninety-five percent of the welders, after graduation from welding schools, are not adequately trained for our production."

10. "Welding jobs are too variable. Most welders graduating from vocational schools do not possess enough skills in wire feed machines. Most welders do not have enough training to pass company welding tests."

11. "A study like this definitely needed in Tacoma. I hope your efforts will be useful to the educational community here also."

12. "Day courses tend to be structured too broadly, therefore, it takes a student usually three quarters or more to pass our test. We need applicants who can handle Lo/Hi 6010, 6011, and 7018 rods, vertical, overhead position. We do not require prints, gas welding and prefer to instruct them for other welding requirements."

13. "Our firm employs welders experienced in downhill pipe line procedures for gas and oil pipe line and related facility work. Our pipe fabricating shop requires welders with the same skills, but in addition, they are working on ASME code work continually on both carbon and alloy steels. Both categories are sometimes subject to 100% x-ray surveillance."

Question Five and General

14. "More adequately trained semi-automatic welders."

15. "We are a close-tolerance custom fabricating shop. We use heli-arc welders only. Welders must be able to read drawings and weld to close tolerance. We work with all types of light gage metals. (Steel, stainless steel, aluminum, brass)."

16. "We are a small firm employing 11-15 welders and need experienced welders, but I am willing to attempt your questionnaire."

    (1) Basic skills are probably properly presented. Learning practices are apparently with easiest and smallest rod available for most work (except code), it is too slow.

    (2) In a small shop like ours (4), attitude is important. Perhaps a short dissertation on other crafts (for understanding) would be in order (fitting, etc.)."

17. "Welders capable of certifying to Boeing standards would help."

18. "As a welding supervisor and an advisory committee member to the welding school at Clackamas Community College, I feel one of our greatest problems is getting the student to complete a welding program. The majority seem to quit school and take a job (good pay) as soon as they learn to hold an arc."

19. "Our welding shop is a maintenance welding shop. We feel that the welders who graduate from the vocational schools should be certified by the State of Washington."

20. "Changes in state curriculum requirements to begin with low hydrogen and mild steel rather than gas. Also include semi-automatic training."

21. "As we are a small company we use a more versatile welder who has to be a combination welder-fabricator. In busy times we use up to 15 men, one-half of which are fitter-welders, the other half are registered DPW or CWB welders."

22. "Our production welding is done with MIG's with the gun mounted in a holder, and work moving beneath it. Operator has no chance to compensate manually for poor machine settings."

23. "Vocational schools need to be more aware of the expanding opportunities in the nuclear field in the Northwest requiring welding talent. This is maintenance welding, etc., generally on stainless steels and other exotic metals. Quality assurance is a must here too."

24. "First of all the man must have a desire to be a welder."

25. "We need semi-automatic wire welders for ship construction, pipe welders for ship construction. Also wire and stick electrode for ship and rail car line. There is only one way to accomplish these needs - hire competent practical instructors from industry, i.e., men with not less than ten years of actual experience at trade in different processes."

"A student cannot learn to production weld in a booth. There has to be some way to train a man on actual production conditions. Different positions encountered on the job."

Appendix A, Part III

Table Ia

DATA TABULATIONS ON QUESTIONNAIRES SENT

I Preliminary questionnaire.

(1) Copies sent - 280

(2) Copies returned - 85 (30.4%)

(a) Yes - 58 (68%)

(b) No - 27 (32%)

(3) Copies not returned - 195 (69.6%)

(4) Additional questionnaires sent to revised mailing list.

(a) Welder - 29 extras

(b) Welding supervisors - 36 extras

II Welder's questionnaire.

(1) Copies sent - 87

(2) Copies returned - 35 (40.2%)

(3) Copies not returned 52 (59.8%)

III Welding supervisors questionnaire.

(1) Copies sent - 94

(2) Copies returned - 41 (43.6%)

(3) Copies not returned - 54 (56.4%)

IV Control group (national).

(1) Copies sent - 22

(2) Copies returned - 12 (54.5%)

(3) Copies not returned - 10 (45.5%)

Appendix A, Part III

Table 1b

TABULATION OF PRELIMINARY QUESTIONNAIRES

Questionnaires sent - 280.

Returned - 85 (30.4%)

Not returned - 195 (69.6%)

Question one: Cooperate further in study.

Yes - 58 (68%)

No - 27 (32%)

Question two: Does your industrial concern employ welders?

Yes - 67 (79%)

No - 18 (21%)

Question three: What percentage of your welders are hired directly on graduation from vocational schools?

Number and Percentage of Reporting Industries	Percentage of Welders Hired Directly from Schools
29 (42%)	None
4 (6%)	Not sure
4 (6%)	1%
10 (12%)	5%
9 (15%)	10%
3 (4%)	20%
2 (3%)	25%
2 (3%)	33%
1 (1%)	40%
1 (1%)	70%

Question four: Do you feel the welder should be more adequately trained by the schools for your welding needs?"

Yes - 54 (87%)

No - 4 (6.4%)

Undecided - 4 (6.4%)

Appendix A, Part III (Continued)

Question five: Information from which revised welding curriculum may be developed to reflect your industrial needs can be provided by allowing a typical production welder and a welding supervisor to fill out a questionnaire describing their duties.

Cooperate further.

Yes - 58 (70%)

No - 25 (30%)

Appendix B, Part 1

Question four - Certification or Weld Test Requirements

	Type of Test	Number of Industries Reporting	
1.	ASME code vessel	1	2.8%
2.	MA 1	2	5.7%
3.	Navy or Coast Guard	2	5.7%
4.	AWS (City Certification)	2	5.7%
5.	Shop standard	1	2.8%
6.	Butt test with 7018	1	2.8%
7.	3/8 plate - two position	2	5.7%
8.	General maintenance machinist	1	2.8%
9.	As much experience as possible	1	2.8%
10.	Minimum on MIG machine	1	2.8%
11.	Visual	1	2.8%
12.	No comments given	20	57.0%

Appendix B, Part 2

Question five - Union Affiliation

		Respondents	
1.	Machinists	8	22.8%
2.	Molders	1	2.8%
3.	Operating Engineers	1	2.8%
4.	Boilermakers	1	2.8%
5.	Iron Workers	8	22.8%
6.	Plumbers and Fitters UA Local 32	1	2.8%
7.	No comment given	15	42.7%

Appendix B, Part 3

Question seven - Recruiting procedures used by industries

Procedure	Number	Percentage
1. State employment service	2	5%
2. Private employment service	1	2%
3. Advertisement in local papers	5	12%
4. Union halls	14	33%
5. Welding schools	6	14%
6. College vocational program	3	7%
7. Employer sought employee	1	2%
8. Hired directly into production job	5	12%
9. Employers school by bid arrangement	1	2%
10. Soliciting	1	2%
11. Prior experience	2	5%
12. Friends related job opening	1	2%
13. Employers list of known welders	1	2%

Appendix B, Part 4

Question eight - Respondents Educational Grade Level

Grade Level	Number of Respondents	Percentage
7	1	3%
8	1	3%
9	1	3%
10	1	3%
11	2	6%
12	19	58%
13	5	15%
14	3	9%
GED	2	6%

Appendix B, Part 5

Question nine - Type of Schools Respondent Attended for Welding Training

School Type	Number	Percentage
1. Community college welding program	5	11%
2. Vocational school welding program	18	38%
3. High school vocational welding program	5	11%
4. On-the-job training (OJT)	7	15%
5. Self taught	4	9%
6. Apprenticeship program	3	6%
7. Home study	1	2%
8. US Army training	1	2%
9. US Navy training	2	4%
10. US Air Force training	1	2%
11. War production training	1	2%

Appendix B, Part 6

Question 10 - Comments from welders' questionnaires
"Was welding training adequate?"

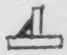
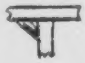
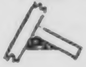
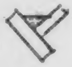
1. "It got my foot in the door as a blacksmith welder - as a blacksmith helper (1934)."
2. "I could arc weld long before I could gas weld."
3. "General knowledge of diverse welding technology."
4. "School was only for basic lab work and bead practice."
5. "My training for stick welding, but should also have been for automatic MIG and TIG welding."
6. "Was able to pass welding test, but not able to perform satisfactory work outside of test booth on poorly fit or dirty material, or in odd position."
7. "Lack of odd circumstances in welding such as gaps, tight spots, how and why's of welding different steels, weld symbols and weld sizes."
8. "U.S. Navy welding school had a very good program, the school lasted for 14 months at 40 hours a week."
9. "Not enough space or time."
10. "Training was adequate for plate and structural but not for present pipe job."
11. "Not enough practical experience with metal and characteristics of same."
12. "Not full enough coverage."

Appendix B, Part 7

Questions 11 through 35 - Comments

1. Question 34 - "Vertical butt or fillet-weave or stringer depends on mode, size and specifications."

2. "Recommend all students be given ample time on stringer beads over weave."

3. (a) Horizontal fillet in the flat position.  (a)
   (b) Horizontal fillet in the overhead position  (b)
   (c) Overhead fillet  (c)  (d)
   (d) Flat fillet

4. Question 35b - "All these electrodes will weld in butt and fillet joint in flat and horizontal position."

5. "All welding done with MIG and TIG."

6. "Note - in this plant we use only TIG and MIG processes."

7. "Does not apply in this shop."

8. "I was a pipe welder before coming to Freightliner, and Freightliner doesn't use electrodes, TIG and MIG only."

Appendix B, Part 8

General Comments - Welders

1. "My type of work is mostly MIG, flat fillet work. I have to do maintenance in plant with stick rod all position, low, high and all purpose rods. I work on case iron molds with cast iron rods. In school we had to pass certification on all machines, MIG, TIG, dual shield, stick rod, and oxy-acetylene welder - all position root beads, drag, back up strip."

2. "I am not a production welder. All I do is arc out defects in castings and fill them back up with the right specified rod."

3. "We do not have any production welding in our spring plant. What welding we have consists of welding wear pads and threaded bushings on spring main leaves using low-hydrogen 1/8, E7018. We do make our own racks and frames for use in the shop."

Appendix B, Part 8 (Continued)

4. "Using flux core 1/16 wire, I weave with the MIG on vertical up and to a certain extent on overhead."

5. "Men employed by us are all journeymen machinists."

6. "All our processes require stringer beads, including vertical."

7. "We are using almost exclusively the flux core arc welding process in all positions and all types of joints. The wire used in all positions and all types of joints. The wire used is Linde FC707, 1/16 diameter, all position E70T-1."

8. "In the plant where I work all welding is done on benches and using MIG and TIG process. This survey is a good idea and schools should keep in touch with industry on welding procedures used."

9. "Oxy does not apply in our work. In most cases stringer beads except vertical. Some prefer weave on vertical."

10. "These are skills that a person applying as a welder should know to call himself a journeyman."

11. "Every welder should know the proper usage of the cutting torch."

12. "TIG and MIG are good things to know but not necessary. Stick (hand) welding of butt and fillet type joints are a must. Mostly mild steels are used but should be able to use 7018 and stainless alloy rods. 7024 rod should be taught for fillet welds. Most schools don't. Oxy welding should be taught on pipe only. Should be able to use 6011, 7018 and S.S. on pipe.

    I find that most men welders try to weld cold. Need to learn to turn their machines up. Most need to learn how to tack, small hot tack, not large tacks."

13. "Weave beads are fast becoming nonacceptable for code welds of any type. Stainless steel procedures should be taught. You would only need the butt and fillet type of joints. Vertical and overhead positions."

Table II

WELDER'S QUESTIONNAIRE DATA TABULATION

General questions:

1. Respondents' names not given to secure their identity.
2. Alphabetized listing of industrial concerns represented within this study have been provided by Appendix F, page 104.
3. Products produced by responding industries have been listed in Appendix H, Part I, page 62.
4. Employment entry skill level:
    - (a) Experience requirements
        - Yes - 13 (38%)
        - No - 7 (20%)
        - No Comment - 15 (42%)
    - (b) Weld test or certification required
        - Yes - 19 (54%)
        - No - 8 (23%)
        - No Comments - 8 (23%)
    - (c) For comments see Appendix B, Part I, page 62.
5. Union affiliation
    - (a) Yes - 24 (69%)
    - (b) No - 3 (9%)
    - (c) No comment 8 (23%)
    - (d) For comments see Appendix B, Part 2, page 62.
6. Physical examination requirements
    - (a) Yes - 11 (31%)
    - (b) No - 21 (64%)
    - (c) No comment - 1 (3%)

7. Welder recruitment procedures - See Appendix B, Part 3, page 63.

8. Highest grade level completed - See Appendix B, Part 4, page 63.

9. Type of welding training schools attended by respondents - See Appendix B, Part 5, page 64.

10. Was your vocational welding training adequate for your entry level employment needs?

    (a) Yes - 21 (60%)

    (b) No - 12 (34%)

    (c) No comment - 2 (6%)

    (d) For comments see Appendix B, Part 6, page 65

Basic Education: (Numbers listed in percentages)

	N	D.	U*
11. Mathematical problem solving ability encompassing arithmetic through basic algebra.	9	54	37
12. Basic understanding and application of scientific laws as related to mechanics, i.e., (levers).	17	48	34
13. Human relations:			
(a) Welder-supervisor relations	51	40	9
(b) Welder-fellow work man relations	51	43	6
(c) Welder-society relations	23	51	26
14. Communications:			
(a) Write reports	11	32	57
(b) Verbally direct others	23	66	11
(c) Receive verbal communications	94	6	0

*N - Necessary, D - Desirable, U - Unnecessary

Table II (Continued)

		N	D	U
15.	Economics as related to:			
	(a) Employment	20	54	26
	(b) Income and taxes	14	34	52
	(c) Industrial organizations	14	49	37
	(d) Family finance management	23	40	37
Welding Related Knowledge Requirements				
16.	Interpret blueprints, shop drawings and welding symbols	69	29	2
17.	Ability to make simple pictorial and three-view drawings	34	46	20
18.	Ability to interpret and use drawings related to hydraulic and pneumatic systems	0	49	51
19.	Ability to interpret and use electrical drawings related to welding equipment	3	46	51
20.	Knowledge of weld characteristics of:			
	(a) Low and medium carbon steel	71	23	6
	(b) Low alloy steels, i.e., (TI)	71	23	6
	(c) High alloy steels, i.e., (347)	57	37	32
	(d) Aluminum alloys	46	34	20
	(e) Magnesium alloys	31	37	32
	(f) Titanium alloys	29	29	42
21	Heat treating of metals:			
	(a) Annealing	17	35	34
	(b) Normalizing	29	37	34
	(c) Hardening	14	52	34
	(d) Tempering or drawing	14	52	34

Table II (Continued)

		N	D	U
22.	Understanding of electricity as related to:			
	(a) AC-DC rectifier welding power source	23	51	26
	(b) Motor-generator welding power source	23	52	20
	(c) Alternating current power source	17	63	20
23.	Characteristics of metals as related to weldability, melting point, yield point, tensile strength, brittleness, expansion and contraction	48	43	9
24.	Understanding of design for welded structure	40	40	20
25.	Understanding of basic type joints and their characteristics when welded	63	23	14
26.	Welding and its affect on heat-treated metals	57	31	12
27.	Understanding of the terms and processes of welding	69	29	2
28.	Understanding of the characteristics of a quality weld	80	17	3
29.	Understanding of the testing and inspection process	31	57	12
30.	Understanding of welding related cost factors	29	48	23
31.	Production related:			
	(a) Understanding of the possibility and limitations of various cutting processes with respect to metals and their alloys used in industry.	40	34	26
	(b) Understanding of the codes and specifications related to welding; such as pressure vessels, piping, building safety, etc.	34	43	23

Table II (Continued)

		N	D	U
(c)	Understanding of welding sequences as related to distortion	74	20	6
(d)	An awareness of hazardous fumes and gases when welding on certain materials	80	17	3
Welder's Related Skills and Functions:				
32.	Equipment operation			
(a)	Press brake	17	31	52
(b)	Punch	11	37	52
(c)	Band saw	26	34	40
(d)	Grinders and sanders	63	20	17
(e)	Squaring shear brade, nibbler, etc.	23	29	48
(f)	Efficient use of small hand tools	60	23	17
(g)	Drilling equipment	34	37	29
(h)	Lathe, shaper, mill, etc.	3	14	83
(i)	Jigs-fixtures	49	31	20
(j)	Power shear	23	37	40
(k)	Hydraulic lifts	17	26	57
(l)	Pneumatic systems	11	32	57
(m)	Taps, dies, reamers	43	17	40
33.	Welding related functions			
(a)	Oxyacetylene gouging	37	31	32
(b)	Arc gouging	66	23	11
(c)	Machine cutting	37	40	23
(d)	Repair welding machines	6	49	45

Table II (Continued)

		N	D	U
(e)	Read and interpret prints for job	66	26	8
(f)	Perform job layout	37	46	17
(g)	Fit up for job	66	23	11
(h)	Repair welding machine leads and grounds	34	46	20
(i)	Select materials for job	49	37	14
(j)	Select electrodes for job	71	20	9
(k)	Perform Hardfacing	34	34	32
(l)	Position for welding	74	23	3
(m)	Heat treating of metals	17	40	43
(n)	Metal spraying and finishing	2	29	69
(o)	Automated equipment welding related	34	49	17

TABLE II (continued)

MANIPULATIVE SKILLS FOR A PRODUCTION WELDOR

34. Check in spaces provided for each type of joint:		butt				lap				fillet				corner				edge			
	Weld process	oxy	arc	TIG	MIG	oxy	arc	TIG	MIG	oxy	arc	TIG	MIG	oxy	arc	TIG	MIG	oxy	arc	TIG	MIG
a. In columns below each joint check positions weld process is used.	Flat weld	52	47	72	[illegible]	45	74	61	77	45	57	61	[illegible]	42	87	65	74	35	71	52	61
	Horizontal	45	67	58	65	45	81	59	71	45	72	61	77	42	72	65	71	31	74	55	55
	Vertical	36	37	55	55	36	54	55	55	36	40	58	58	42	87	55	52	35	84	51	45
	Overhead	29	52	40	42	29	51	52	45	13	42	48	40	26	77	45	39	29	81	43	36
b. In columns below each type of joint check processes used for weave or stringer beads.	Stringer beads	32	77	42	65	32	71	45	61	32	74	78	65	32	77	55	65	35	74	52	55
	weave	23	55	26	35	16	52	19	36	16	36	16	39	16	16	16	39	10	26	13	29
	other	3	6	3	6	3	7	3	6	3	7	3	6	3	7	3	6	3	6	3	6

(Percentages based upon 31 respondents)

TABLE II (continued)

MANIPULATIVE SKILLS FOR A PRODUCTION WELDOR (Continued)

35. Check in space provided opposite each type of joint:
    a. Check type of weld used for each joint show: i.e. (weave).
    b. Check electrodes used for each type of joint in columns opposite size shown.

36. In column opposite type of joint check:
    a. Metal thickness used.
    b. Metal shapes used.
    c. Type of metal used.

	a.		b.								a.				b.					c.						
	Stringer	Weave	E6010	E6011	E6012	E6013	E7018	E7024	E7028	Electrode size	Sheet metal	3/16-1/4	5/16-3/8	1/2 and thicker	Pipe	Angle	Channel	"I" beam	Round	Mild steel	Low alloy	High alloy	Aluminum	Titanium		
Butt	100	71	33	29	12	17	42	21	12	3/32	58	33	29	33	50	50	46	42	50	54	42	42	42	12		
	75	75	46	46	12	25	71	42	12	1/8	33	58	63	33	67	54	50	54	50	63	54	33	33	12		
	92	71	33	46	8	17	75	46	25	5/32	12	42	63	50	46	50	50	50	92	54	46	33	17	4		
	71	67	25	21	8	12	[illegible]	29	21	3/16	12	25	38	50	29	21	38	33	21	46	33	21	12	4		
	42	67	[illegible]	12	[illegible]	12	21	33	25	1/4	8	17	17	25	12	17	17	17	17	17	8	4	8	4		
Fillet	75	50	21	25	12	17	42	21	12	3/32	50	29	25	[illegible]	33	33	33	29	42	50	33	38	33	12		
	79	75	21	46	12	21	67	50	21	1/8	42	67	46	33	33	46	46	46	29	50	71	33	29	17		
	83	58	29	38	12	17	71	50	33	5/32	12	54	58	54	33	50	46	46	33	63	46	42	21	8		
	58	58	21	29	8	12	63	50	21	3/16	8	21	33	54	21	33	29	29	54	46	33	25	21	8		
	33	[illegible]	12	19	8	12	25	42	25	1/4	8	12	21	38	12	21	17	17	21	38	12	8	12	4		
Corner	71	46	21	25	12	17	42	21	8	3/32	50	29	21	21	33	29	29	21	29	50	38	33	38	8		
	79	46	29	42	12	21	71	42	21	1/8	42	67	54	25	25	50	46	46	29	54	42	25	21	4		
	79	46	25	33	8	17	75	50	25	5/32	17	50	54	50	25	38	33	38	29	63	38	25	17	0		
	71	46	17	21	8	12	42	38	17	3/16	8	25	33	46	17	29	33	33	29	38	29	12	8	0		
	79	46	8	12	8	12	25	29	17	1/4	8	[illegible]	12	25	8	12	12	17	12	21	8	4	8	0		
Lap	79	42	21	25	12	17	42	17	8	3/32	46	33	25	25	33	29	29	29	21	46	21	33	38	8		
	79	42	29	38	12	[illegible]	75	50	21	1/8	38	54	54	25	33	42	42	29	21	58	33	25	25	4		
	71	37	25	38	8	8	63	42	25	5/32	8	46	58	46	33	42	42	33	8	50	38	21	13	0		
	79	42	21	25	12	12	46	42	17	3/16	8	25	42	50	33	42	42	33	17	50	29	12	12	0		
	75	42	12	12	8	12	33	25	12	1/4	8	12	17	25	8	17	12	12	8	21	8	4	8	0		
Edge	67	37	21	29	12	17	46	12	4	3/32	46	29	17	17	25	25	25	25	12	50	29	25	38	12		
	67	37	21	38	12	21	54	25	8	1/8	33	63	46	29	21	33	42	38	21	54	38	25	25	4		
	63	37	25	29	[illegible]	12	54	25	12	5/32	12	46	46	38	21	33	33	33	21	29	38	21	8	0		
	63	37	17	17	8	8	42	21	8	3/16	8	8	25	33	12	25	25	25	12	21	21	12	8	0		
	59	33	8	12	8	8	21	12	8	1/4	8	8	8	8	8	8	8	8	8	8	4	4	8	0		

(Percentages based upon 24 respondents)

Appendix C, Part 1a

Question four - Experience Requirements (Welding Supervisors)

	Respondents Number (Percentage)
"The ability to weld."	4 (9.7%)
"Six months"	2 (5.0%)
"Four years or journeyman."	4 (9.7%)
"Five years or journeyman."	4 (9.7%)
"Vocational school or equivalent."	3 (7.0%)
"TIG and MIG on stainless steel"	1 (2.4%)
"Apprenticeship."	1 (2.4%)
"General shop experience."	3 (7%)
"Prior plate pressure level."	1 (2.4%)

Appendix C, Part 1b

Question four - Experience Requirements (Control Group)

"Variable experience."	1 (12.5%)
"One to two years."	1 (12.5%)
"Apprenticeship."	1 (12.5%)
"Vocational school or equal."	1 (12.5%)
"Journeyman."	3 (37.5%)
"Ability to pass pipe test."	1 (12.5%)

Appendix C, Part 2a

Question four - Types of Certification (Welding Supervisors)

	Respondents Number (Percentage)
Navy (MAI)	3 (7.0%)
Coast Guard	1 (2.4%)
ABS	1 (2.4%)
MIL-1-5021 Class A-1	1 (2.4%)
AWS	1 (2.4%)
ASME Sect. IV, (3/8 Plate vertical, E7018 filler metal)	3 (7.0%)
Seattle certification	1 (2.4%)
MIL 248	1 (2.4%)
AWWA	1 (2.4%)
Low hydrogen E7018 - vertical & overhead	1 (2.4%)
Mid-mountain standard shop test	1 (2.4%)
Visual inspection	2 (4.8%)
Three position plate test	1 (2.4%)
No comment	23 (56%)

Appendix C, Part 2b

Question four - Type of Certification (Control Group)

Three position tack test	1 (14%)
Three position test	1 (14%)
API	1 (14%)
AWS	1 (14%)
ASME Section IX (Code)	3 (43%)

Appendix C, Part 3a

Question five - Union Affilitation (Welding Supervisors)

IAM 1005
Boiler Makers
Assortment of Sheet Metal Workers
CIO Steel Workers
Machinists
Iron Workers NTM
AF of L
Molders and Allied Workers #158
UFWE
Pile Drivers
Pipe Fitters
IADMF
United Association of Plumbers and Fitters

Appendix C, Part 3b

Question five - Union Affiliation (Control Group)

United Steel Workers
International Brotherhood Boilermakers & Ship Builders, Local 443
CIO
Smith Steel Workers DALU 19806 AFL-CIO
US, Boilermakers, Ironworkers, and Electricians
Ironworkers, (International Association of Bridge Structural)

Appendix C, Part 4a

Question eleven - "Was welding training adequate?" (Welding Supervisors)

1. "We must do additional training for most because of lack of experience."

2. "Able to pass welding test but not able to perform adequately on the job."

3. "Most welders lacked gas tungsten arc experience."

4. "Schools do not teach semi-automatic, so men trained not trained good enough."

5. "Lack understanding of materials, equipment and processes."

6. "Slow, unsure, lack of production experience."

7. "Lack of practical experience."

8. "Most need more experience with low hydrogen electrodes and semi-automatic welding machines; should understand weld symbols."

9. "No training in dual shield-cored wire."

10. "Depends on how well equipped the school is. If the school does not have arc-gouging or x-ray, then welders are generally not satisfactory for anything but talking."

11. "Too much out of position taught - not enough speed rod production fact."

12. "Semi-automatic wire fed machine."

13. "Most employed as helpers unless journeymen previously."

14. "We train after successful bidding."

15. "Lack of training on automatic equipment - lack of experience on actual job situations. (We don't spend our day welding scrap iron together."

16. "Welders lacking in basic skills. I believe too much emphasis is placed on diversity not necessary to employment. A skilled or well taught stick welder can be taught semi-automatic, heli-weld, etc., on the job very easily, if he has basic skills well in hand."

17. "Not at journeyman level - okay as helper."

18. "No knowledge of alloy steel welding electrodes or heat effected zones."

19. "This type of training received at community colleges is considered sufficient only as preparation training for apprentices."

20. "Do not know how to weld - think they are good welders."

21. "Not full enough coverage."

22. "Welders may pass qualification tests, but could not weld on actual weldments without additional experience."

23. "Lack semi-automatic (Dual shield and solid wire)."

24. "We use our welders where knowledge of blue prints is needed."

Appendix C, Part 4b

Question eleven - "Was welding training adequate?" (Control Group)

1. "Not able to weld in all three positions - completely unfamiliar with heavy machinery."

2. "This depends on the individual skill - some will never make good welders."

3. "Lack of overall understanding."

4. "Problems - all employees have to obtain a job in the mill before they can get a bid into an apprenticeship course."

5. "Not equipped for high speed line instruction."

6. "Lacked job experience and work with actual procedures."

7. "Welders are started on flat downhand welding and with experience progress to vertical and overhead."

8. "Not enough actual work experience."

Appendix C, Part 4b (Continued)

9. "Welding in the automotive companies is unique from the rest of industry in that it relies on a predominance of resistance welding processes to fabricate it product. Arc welding assemblies are made with automatic equipment, semi-automatic MIG and flux cored wire, and manual stick electrodes. However, in all instances the operators or welders are given only sufficient training to weld the joint in question and the majority are trained on the job. These can be considered unskilled or at the best, semi-skilled workmen."

10. "Not qualified to pass ASME Section IV Pipe test."

Appendix C, Part 5a

Question twelve - Welders Occupational Ladder Data
(Welding Supervisors)

1. (a) MIG steel welding
   (b) MIG (AL. M.S.) welding
   (c) TIG (AL.) welding

2. (a) Stick
   (b) MIG
   (c) TIG

3. (a) Welder qualification only

4. (a) Foundry welder
   (b) Certified welder

5. (a) General welder maintenance

6. (a) Journeyman welder (only)

7. (a) All types of welders

8. (a) Tackers

9. (a) 1st class welder - welds ASME pressure vessels
   (b) 2nd class welder - welds API and AWWA type vessels and structure
   (c) 3rd class welder - tacker

10. (a) Welder - mild steel with speed rod or semi-automatic

11. (a) Helper - pick up welding, welder's helper, fitter's helper, crane operator
    (b) Specialist - fitters or welders as desired or needed, press brake or shear man
    (c) Journeyman - fitter or welder (certified)

12. (a) Certified ASM welders
    (b) Cast iron repair welder
    (c) Commercial grade welder

13. (a) Foundry welder
    (b) Certified welder

14. (a) Inner shield - on rotator
    (b) CO_2 - fillets
    (c) Stick welds - all positions
    (d) Hard surface - building up surface

15. (a) Gas welder - M.S., all position
(b) MIG - al., all position
(c) TIG - al. and steel, all position

16. (a) Welder - noncode, nonpressure
(b) Certified welder - on code work - stick and automatic

17. (a) Journeyman only - do all welding

18. (a) Helper
(b) Limited welder
(c) Welder
(d) Welder special
(e) Welder instructor

19. (a) Welder - pipe in all position
(b) Welder - mild steel in flat position
(c) Welder - operator submerged arc

20. (a) Tacker does all welding (general)

21. (a) Burner - hand torch and auto - M. S. and S. S.
(b) Welder- welds all positions on ferrous and nonferrous

22. (a) All welds through HY 80 material (steel)
(b) Pipe - C.S., chrome-moly, S.S.
(c) All welding manual shield metal arc, TIG, MIG, sub-arc

23. (a) Weld mild steel flat

24 (a) Tacker
(b) Welder
(c) Lead welder
(d) Supervisor

25. (a) No tackers hired

26. (a) Weld pipe in all positions and all modes

Appendix C, Part 5b

Question twelve - Welder Occupational Ladder Data (Control Group)

1. (a) Welder apprentice - three years
   (b) Welder standard - uses all processes, positions and materials

2. (a) Structural - all positions
   (b) Pipe - pressure pipe, all positions
   (c) Aluminum - weld aluminum and structural, all positions
   (d) Brazers - brazes structural pipe, all positions

3. (a) Welder I - general taska
   (b) Welder II - special processes, TIG, MIG, etc.
   (c) Welder supervisor - layout and supervise welders
   (d) Weld engineer - engineering of welding

4 (a) All types

5. (a) Welder I
   (b) Welder II
   (c) Standard
   (d) Department

6. (a) Welder - C.S., production line, stick and MIG
   (b) Combination welder - SMAW, GMAW, and oxy-acetylene - cut and weld
   (c) Heavy repair welder - SMAW, GMAW, and oxy-acetylene - cut and weld, read blueprints
   (d) Tool and die welder - SMAW, GMAW, and GTAW on tool steel

7. (a) Apprentice - tacks M.S., all position and FHP position
   (b) Journeyman - weld with all processes, position and materials

8. (a) Welders - pipe and plate in all positions

9. (a) Semi-skilled production welder - one process per man

10. (a) Fitter welder - pipe, all positions - C.S.
    (b) Fitter welder - pipe, all positions - alloy steel
    (c) Boilermaker welder - alloy pipe, pipe, all positions

11. (a) Welder journeyman - welds all positions M.S.
    (b) Pipe code - welds pipe in all positions
    (c) Pipe code - welds pressure pipe in all positions
    (d) Leadmen - beginning of supervisory training - experience in all phases of welding

Appendix C, Part 6a

Question thirteen through thirty-three Knowledge Requirements (Welding Supervisor)

Question twenty-two

1. Mild Steel
2. Stainless steel and brass
3. Pot metal welds
4. Nickel alloys and cobalt alloys
5. inconnel
6. Ni-rods, etc.
7. High yield 80 and 100
8. Cast iron, brass, bronze
9. Copper, nickel, all other copper-nickel related alloys
10. Copper nickel

Question thirty-three

1. Arc-air, powder, oxy-acetylene
2. ASME

Appendix C, Part 6b

Question thirteen through thirty-three (Control Group)

Question twenty-two

1. Field welder should have equal facility with SMAW and GTAW processes
2. High nickel alloys (i.e., monel)

Appendix C, Part 6b (Continued)

Question twenty-three

1. Stress relieving

Question thirty-three

1. High degree of proficiency in use of the cutting torch is considered essential to construction.

Appendix C, Part 7b

Question thirty-four - Weld Training Facilities (Control Group)

1. "This is the best way."
2. "Definitely - less headaches."
3. "I feel that combined efforts of all will be necessary."
4. "We should move in the direction of area technical school."
5. "Union trained and upgraded."
6. "My experience is that type of training has very little value in our shipyard."
7. "Trade schools were the person pays to learn."
8. "We find the best man to enter the welding trade is one who pays his way - we know that a man who pays to learn wants to be a welder. Government paid courses who force a man to go to school has been a poor system for obtaining good welder."
9. "Some union training and upgrading classes."
10. "Ford - The company in the Dearborn area conducts an apprentice program for tool and die welders. At the end of 8000 hours of one-the-job training, plus academic achievement in 32 courses, the man is given a journeyman's card in tool and die welding. Graduates from this program staff the maintenance departments of our manufacturing plants. They are never utilized as production welders."

Appendix C, Part 8b

Question thirty-five - Weld Processes (Control Group)

1. "Sub arc (SAW)"
2. Electro slag (EW)"
3. "Automatic welding"
4. "Electron beam"
5. "Laser"
6. "Eb. and ES"
7. "SAW"
8. "Submerged arc"
9. Automatic

Appendix C, Part 9b

Question thirty-six - Certification (Control Group)

1. "Certification - (no) - requirements vary greatly also economy of testing"
2. "Teach - code requirements"
3. "School certs are not accepted by code oriented welding fabricators"
4. "Except for training with test plates"

Appendix C, Part 10a

Question thirty-seven - Certification, School-Industry Relationship (Welding Supervisors)

1. "Eventually welders will soon come in contact with all type of specification and most will refer to our national codes."

2. "The foundry process of arcing out defects and making a homogenous fill should be included in vocational training curriculums in areas where foundries are located."

3. "All welders should be state licensed and possibly qualified through schools, industry and state labs."

4. "Welders should have studied the standard welding symbols AWS A2.0 - 68 or a similar AWS book. I personally like this one best."

5. "Not necessary for welder, welding supervisor or foreman, or engineer instruct the welder on what is necessary."

6. "My experience with school trained welders has been this. Too much training in areas that are never used in a structural shop. IUR had men in here, out of school that can run a vertical in stainless and do not know what 7024 rod is. 99% of our welding is flat production work."

7. "I have been employed at Nelson Iron Works, Inc., for 21 years, 6 years as a supervisor. I found our work requires special training for our fork welding. We have a procedure which we follow, so we train our welders for this work."

8. "For familiarization purposes only."

9. "ASME, AWS especially."

10. "The schools should teach different types of code requirements but should not give certifications. The certifications they receive are not always used in our type of industry."

11. "Most welders who we employ do not understand the quality requirements of code construction and do not do work up to quality standards without constant supervision. Requirements of these quality standards should be well imbedded in the student's mind. Industry cannot afford poor workmanship."

Appendix C, Part 10a (Continued)

12. "Again we need standardization; familiarization is required of existing codes."

13. "So student will have an idea of what is expected of him in the field."

14. "This is good if you know which code requirements he will be working with. #36 and #37 should be advanced courses when the individual is ready to learn tough phases."

15. "Teach welder the necessity to use approved materials and adher to sound welding practices."

Appendix C, Part 10b

Question thirty-seven - Certification, School-Industry Relationship (Control Group)

1. "We have observed that a student in a vocational school does not learn as much as he could from the time they have spent studying and in-shop practice. We also have found schools concentrating students on passing weld tests rather than broadening their knowledge of welding."

2. "Teach code requirements, basic metallurgy, weld stress, shrinkage, sequence, heat treatment, inspection (NDT), etc."

3. "Welding schools should be involved in all phases of welding on a progressive basis."

4. "This area is growing each year and a code course is needed."

5. "Only with regard to materials, consumables, qualifications, essential variables, limitations, preheating, and postheating."

6. "A more versatile and varied certification program of certification in specialist skills should be promoted."

7. "We find that one big assist in getting welders is our own training school after work where a helper goes to school on his own time because he wants to upgrade. A welder who is forced to attend a school in order to receive a welfare check very seldom follows the trade after obtaining his job."

8. "If this is done, it must be absolutely up to date at all times, as AWS welding codes are upgraded twice a year."

Appendix C, Part 11a

Question thirty-eight - General Comments - Cooperative Training (Welding Supervisors)

1. "Try to train certain people with definite capabilities to fit in certain welding fields."

2. "In special individual cases for superior students."

3. "Develop weld instruction around how-to-weld program. Industry will teach how to work and make best use of ability. Unions should work to provide entry level welding positions with pay advances after experience."

4. "In a lot of cases they cover too much of one subject and not enough of another, depending on job welder will be doing."

5. "At present time many apprenticeship programs are affiliated with vocational schools."

6. "Federal funding through MARAD or equivalent governmental organizations, i.e., HEW."

7. "More visitations of students to the industries they are training to weld in. Visitation of welder supervisors to welding schools."

8. "Should have closer contact with industry for their needs such as MIG type, etc."

9. "Perhaps an apprenticeship program with industry through local unions."

Appendix C, Part 11b

Question thirty-eight - General Comments - Cooperative Training (Control Group)

1. "I hold reservations about answering this question because it could be a help or hinderance to the welder and also a handicap to the industry. As I mentioned before, we have found the apprenticeship program the most rewarding."

2. "Basic should be taught at weld school - for education - students join local AWS section ($5.00 year) and participate in their educational activities and programs."

3. "Survey of industrial needs in accordance with the area served. This should be done though the cooperation of industry, technical societies, or any possible means of survey to permit the updating of schools for this purpose."

4. "Set up programs of instruction to suit local industries. Work with these industries so school will know about all of the new processes and methods being used in industry. Run programs as a work day not a school day. People are being trained for industry not for school. Semester breaks and holiday weeks off are not industry methods. Train people to be workers and to have a respect for tools and themselves on the job. Too many people get hurt because of lack of knowledge in the use of equipment and how to handle themselves in a plant. Safety is very important and working safely. People need to be more conscientious about their jobs and their company so they will survive and their company."

5. "This area is the big problem in welding training - need to combine the vocational or area tech school with the union and industry."

6. "Coop programs similar to those employed by some colleges and universities."

7. "Yes - only with regard to providing possible upgrade and/or refresher training and determining the needs of industry. Some fab shops may employ school graduates but the construction industries cannot use until they have learned how to work and use the tools."

8. "By running special classes to improve skills in new methods or equipment as needed by industry for their permanent staff of welders."

Appendix C, Part 11b (Continued)

9. "By having instructor work a quarter a year in industry, and get at least one new welding certification each year."

TABLE III

COMPARATIVE TABULATION OF THE NEEDS AND REQUIREMENTS FOR THE TRAINING OF WELDERS

Questionnaires

(a) Supervisors - sent 94, returned 41 (43.6%)
(b) Control Group - sent 22, returned 12 (54.5%)

1. Name of respondents
    (a) Supervisors - not listed
    (b) Control Group - Appendix E, page 103

2. Name of industry
    (a) Supervisors - Appendix D, page 101
    (b) Control Group - Appendix E, page 103

3. Type of products manufactured
    (a) Supervisors - Appendix F, Part 2, page 106
    (b) Control Group - Appendix F, Part 3, page 106

4. Employment skill level requirements
    (a) Supervisors
        (1) Yes - 28 (64%)
        (2) No - 6 (19.6%)
        (3) No comment - 7 (17%)
    (b) Control Group
        (1) Yes - 4 (33%)
        (2) No - 4 (33%)
        (3) No comment - 4 (33%)

    Experience required
    (a) Supervisors - Appendix C, Part 1a
    (b) Control Group - Appendix C, part 1b

    Weld test or certification required
    (a) Supervisors - Appendix C, Part 2a
        (1) Yes - 12 (29%)
        (2) No - 15 (37%)
        (3) No comment - 14 (39%)
    (b) Control Group - Appendix C, Part 3b
        (1) Yes - 8 (66%)
        (2) No - 2 (17%)
        (3) No comment - 2 (17%)

5. Union affiliation
    (a) Supervisors - Appendix C, Part 3a
        (1) Yes - 31 (75.6%)
        (2) No - 6 (14.4%)
        (3) No comment 4 (9.6%)
    (b) Control Group - Appendix C, Part 3b
        (1) Yes - 8 (72%)
        (2) No - 0 (0%)
        (3) No comment - 4 (33%)

TABLE III (Continued)

6. Number of welders represented
   - (a) Supervisors - 3386
   - (b) Control Group - 5292

7. Physical examination requirements
   - (a) Supervisors
     - (1) Yes - 19 (46%)
     - (2) No - 22 (54%)
   - (b) Control Group
     - (1) Yes - 6 (50%)
     - (2) No - 4 (33%)
     - (3) No comment - 2 (17%)

8. Welder recruitment
   - (a) Supervisors - Table III, page 91
   - (b) Control Group - Table III, page 91

9. General education requirements
   - (a) Supervisors
     - (1) Yes - 6 (15%)
     - (2) No - 32 (80%)
     - (3) No comment - 2 (5%)
   - (b) Control Group
     - (1) Yes - 1 (8%)
     - (2) No - 7 (58%)
     - (3) No comment 4 (34%)

10. Welding training provided
    - (a) Supervisors - Table III, page 91
      - (1) Yes - 15 (36%)
      - (2) No - 21 (51%)
    - (b) Control Group - Table III, page 91
      - (1) Yes - 4 (33%)
      - (2) No - 7 (59%)

11. Was welder training adequate?
    - (a) Supervisors - Appendix C, Part 4a
      - (1) Yes - 15 (36%)
      - (2) No - 21 (51%)
    - (b) Control Group - Appendix C, Part 4b
      - (1) Yes - 4 (33%)
      - (2) No - 7 (59%)

12. Occupational ladder
    - (a) Supervisors - Appendix C, Part 5a
    - (b) Control Group - Appendix C, Part 5b

TABLE III (Continued)

Question seven - By which of the following methods are welders recruited for employment?

		Weld Supervisors	Control Group
1.	State employment service	17 (41%)	6 (50%)
2.	Private employment service	10 (24%)	3 (25%)
3.	Advertisement in local papers	18 (44%)	6 (50%)
4.	Union halls	25 (61%)	3 (25%)
5.	Welding schools	20 (49%)	5 (42%)
6.	Friends and relatives	5 (12%)	-------
7.	Company employment service	8 (19%)	1 (8%)
8.	Civil service	2 (5%)	-------
9.	Job bid - in plant	1 (3%)	-------
10.	Pool of entry workers in plant	1 (3%)	-------
11.	Apprenticeship	-------	1 (8%)
12.	Company welding schools	-------	3 (25%)

Question nine - Your welders were trained principally by?

1.	Community college	11 (27%)	3 (25%)
2.	Vocational schools	23 (56%)	8 (66%)
3.	High school vocational programs	4 (9.7%)	-------
4.	On-the-job training (train own)	22 (53.4%)	6 (50%)
5.	Apprenticeship (boilermakers and ironworkers	7 (17%)	2 (17%)

Table III (Continued)

Question twelve - Suggested Ladder based on Summary of Occupational Ladder Data

Weld Supervisors: 41
(Summarized Listing)

Type I:	Responses
1. Helper	3
2. Limited Welder (tacker)	11
3. Welder (journeyman)	11
4. Welder (special)	3
5. Welder (instructor)	3

Type II:	
1. Gas welder	1
2. Burner (hand, auto, MS & SS)	3
3. Stock	3
4. Welder (all positions & materials) TIG, MIG, Sub arc	8
5. Vessels - ASME, API, AWWA	3
6. Pipe - (S.S., C.S., Chrome-Moly)	3

Type III: Special Categories	
1. General Maintenance Welder	2

Type IV:	
1. Foundry Welder	3
2. Certified Commercial Grade	3

Control Group: 12
(Summarized Listing)

Type I	Responses
Welder apprentice	3
Welder standard	2
Welder (journeyman	6
Welder Supervisor	3
Welder Engineer	1

Type II:	
Semi-skilled produc.	1
Welder I	3
Welder II	2
Code	2
Pipe (Code, ASME Navy)	2
Pipe (Code) High Pressure	2

(4.5. & 6. above - Certification)

Type III: Special Cate.	
Heavy repair	1
Tool & die (journeyman	1

Type IV:	
Brazers	1
Aluminum	1

No comment - 13 respondents

Table III (Continued)

These percentages are based on 41 industries for the Welding Supervisor's column, and 12 for the Control Group.

	NC	Welding Supervisors			Control Group		
		N	D	U	N	D	U
Basic Education:							
13. Mathematical problem solving ability encompassing arithmetic through basic algebra.	0	12	51	37	27	45	27
14. Basic understanding and application of scientific laws as related to mechanics: i.e., (levers)	0	7	53	40	36	36	18
15. Human relations:							
a. Welder - supervisor relations	0	53	45	2	36	63	2
b. Welder - peer relations	0	42	48	10	18	72	0
c. Welder - society relations	27	24	37	12	9	72	9
16. Communications:							
a. Write reports	8	12	39	41	9	54	36
b. Verbally direct others	2	24	54	20	18	63	18
c. Receive verbal communications	5	83	12	0	91	9	0
17. Economics as related to:							
a. Employment	27	22	39	12	27	63	9
b. Income and taxes	0	11	36	53	9	45	45
c. Industrial organizations	2	20	37	41	9	45	45
d. Family finance management	4	12	41	43	27	54	18
Welding Related Knowledge Requirements: Welding Supervisors - 40 Control Group - 11							
18. Interpret blueprints, shop drawings and welding symbols.	3	60	29	7	64	27	9
19. Ability to make simple pictorial and three view drawings.	0	5	66	29	46	36	18
20. Ability to interpret and use drawings related to hydraulic and pneumatic systems.	2.5	2.5	27	68	9	45.5	45.5

Table III (Continued)

		Welding Supervisors			Control Group		
	NC	N	D	U	N	D	U
Welding Related Knowledge Requirements (Continued):							
21. Ability to interpret and use electrical drawings related to welding equipment.	2	0	32	66	9	55	36
22. Knowledge of welding characteristics of:							
a. Low and medium carbon steel	0	78	22	5	82	18	0
b. Low alloy steels: i.e. (TI)	2	61	22	12	64	27	9
c. High alloy steels: i.e. (347)	0	51	34	12	55	36	9
d. Aluminum alloys	5	42	32	22	36	55	9
e. Magnesium alloys	7	22	34	37	17	50	33
f. Titanium alloys	5	24	32	39	9	55	36
g. Other							
23. Heat treating of metals:							
a. Annealing	2	22	39	37	18	63	78
b. Normalizing	2	39	34	39	18	63	18
C. Hardening	2	20	37	42	9	55	36
d. Tempering or drawing	7	22	32	39	9	55	36
24. Understanding of electricity as related to:							
a. AC-DC rectifier welding power source	0	22	54	24	36	55	0/9
b. Motor-generator welding power source	0	20	56	24	36	55	0/9
c. Alternating current power source	24	22	51	2	27	63	0/18
25. Characteristics of metals as related to weldability, melting point, tensile strength, brittleness, yield point, expansion and contraction.	2	42	46	10	27	73	0
26. Understanding of design for welded structure.	2	24	44	29	27.5	45	27.5
27. Understanding of basic type joints and their characteristics when welded.	2	63	29	5	45	55	0

Table III (Continued)

		Welding Supervisors			Control Group		
	NC	N	D	U	N	D	U
Welding Related Knowledge Requirements (Continued):							
28. Welding and its affect on heat-treated metals.	0	47	44	9	45	55	0
29. Understanding of the terms and processes of welding.	3	78	17	2	73	18	0
30. Understanding of the characteristics of a quality weld.	3	90	7	2	91	0	0/9NC
31. Understanding of the testing and inspection process.	10	39	39	12	45	55	0
32. Understanding of welding related cost factors.	2	20	56	22	18	55	27
33. Production related:							
a. Understanding of the possibilities and limitations of various cutting processes with respect to metals and their alloys used in industry.	3	22	51	24	27	84	9
b. Understanding of the codes and specifications related to welding; such as, pressure vessels, piping, building safety, etc.	0	29	39	32	18	55	18
c. Understanding of welding sequences as related to distortion.	0	61	34	5	55	36	0/9NC
d. An awareness of hazardous fumes and gases when welding on certain metals.	0	75	20	5	82	9	0/9NC

Table III (Continued)

Questions thirty-four through thirty-eight - percentages for each question based on 41 respondents for Welding Supervisors and 11 for the Control Group.

Question thirty-four - The welder:

Forecasts indicate great numbers of new welders will be needed by industry. Where may these people best be trained?

		Welding Supervisors	Control Group
1.	High school vocational welding classes	11 (27%)	3 (27%)
2.	Private vocational welding classes	11 (27%)	7 (64%)
3.	Post high school vocational welding classes	16 (39%)	5 (46%)
4.	A combination of the three above methods plus industry providing additional on-the-job training relative to their particular needs.	34 (83%)	11 (100%)
5.	Private industry train their own people	11 (27%)	5 (46%)
6.	Vocational-technical schools supportive to industry	3 (7%)	0
7.	Apprentice program	2 (5%)	0

For comments see Appendix C, Part 9b, page 85.

Table III (Continued)

Question thirty-five - Weld process:

			Increase		Decrease		Same	
			W.S.	C.G.	W.S.	C.G.	W.S.	C.G.
1.	Oxy-acetylene	OAW	0	2 (18%)	24(58.6%)	9 (75%)	8(19.5%)	3(27%)
2.	Metallic arc	GW	25 (61%)	8 (72%)	8 (19.5%)	4 (34%)	4 (10%)	3(27%)
3.	Gas metal arc welding (solid core)	GMAW	33 (80.5%)	11 (100%)	2 (5%)	0 —	3 (7%)	1 (9%)
4.	Flux cored arc welding (inner shield)	FCAW	35 (85%)	11 (100%)	0 —	1 (9%)	2 (5%)	1(9%)
5.	Gas tungsten arc welding	GTAW	37 (90%)	7 (64%)	3(7%)	0 —	2 (5%)	0 —
6.	Plasma arc	PAW	33 (80.5%)	8 (72 %)	2 (5%)	0 —	6 (14.6%)	2(18%)
7.	Ultra sonic	USW	31 (75.6%)	8(72%)	3(7%)	0 —	7(17%)	2(18%)
8.	Submerged arc	SAW	0 —	3(27%)	0 —	0 —	2 (5%)	0 —
9.	Automatic	AU	0 —	2 (18%)	0 —	0 —	0 —	0 —

See Appendix C, Part 10b, page 87.

Question thirty-six - Should welding schools be involved with welding certification?

1. Welding supervisors
   (a) Yes - 25 (61%)
   (b) No - 14 (34%)
   (c) No comment - 2 (5%)

2. Control Group
   (a) Yes - 3 (27%)
   (b) No - 8 (73%)

3. See Appendix C, Part 11b, page 89.

Question thirty-seven - Should welding schools be involved with the teaching of welding code requirements?

1. Welding supervisors
   (a) Yes - 37 (90%)
   (b) No - 3 (7%)

2. Control group
   (a) Yes - 11 (100%)
   (b) No - 0

Question thirty-eight - Should welding schools enter into more cooperative educational programs with industry employing welders:

1. Welding supervisors
   (a) Yes - 33 (80.5%)
   (b) No - 5 (12%)
   (c) Other - 3 (7.5%)

2. Control Group
   (a) Yes - 9 (82%)
   (b) No - 1 (9%)
   (c) Other - 1 (9%)

Appendix D

LIST OF INDUSTRIAL CONCERNS

1. A S C Machine Tools
   Spokane, Washington

2. Alaskan Copper
   Seattle, Washington

3. Ameron Pipe Products
   Northwest Division
   Portland, Oregon

4. Anderson & Miller
     Manufacturing Company
   Spokane, Washington

5. Armco Steel Corporation
   Metal Products Division
   Hillsboro, Oregon

6. Atlantic Richfield Hanford
     Company
   Richland, Washington

7. Atlas Foundry & Machine
     Company
   Tacoma, Washington

8. Benz Spring Company
   Portland, Oregon

9. Black Clawson, Inc.
   Everett, Washington

10. Boeing Company
    Seattle, Washington

11. Capital Industries, Inc.
    Seattle, Washington

12. Chicago Bridge & Iron Company
    Birmingham, Alabama

13. Continental Can Company, Inc.
    Walla Walla, Washington

14. Esco Corporation
    Portland, Oregon

15. F W D Wagner, Inc.
    Portland, Oregon

16. Fentron Industries, Inc.
    Seattle, Washington

17. Fick Foundry Company
    Tacoma, Washington

18. Fisherman's Boat Shop, Inc.
    Everett, Washington

19. Freightliner Corporation
    Portland, Oregon

20. Gunderson, Inc.
    A Subsidiary of FMC
      Corporation
    Portland Division
    Portland, Oregon

21. General Machinery Company
    Spokane, Washington

22. Ingersoll Rand Company
    lawrence Division
    Seattle, Washington

23. Kenworth Motor Truck Co.
    Seattle, Washington

24. Lake Union Dry Dock Co.
    Seattle, Washington

25. Leckenby Company
    Seattle, Washington

26. Lockheed Shipbuilding &
      Construction Company
    Seattle, Washington

27. McCullock & Sons
    Portland, Oregon

28. Mid-Mountain Contractors
    Bellevue, Washington

29. Nelson Iron Works
    Seattle, Washington

30. Pacific Car & Foundry Co.
    Renton, Washington

31. Precision Cast Parts Corp.
    Portland, Oregon

32. Puget Sound Naval Shipyard
Bremerton, Washington

33. Reynolds Metals Company
Longview, Washington

34. Seattle Boiler Works, Inc.
Seattle, Washington

35. Skookum Company, Inc.
Portland, Oregon

36. Star Iron & Steel Company
Tacoma, Washington

37. Steel Products, Inc.
Seattle, Washington

38. Todd Shipyards Corporation
Seattle Division
Seattle, Washington

39. U.S. Naval Air Station
Whidbey Island, Ault Field
Oak Harbor, Washington

40. United Iron Works, Inc.
Seattle, Washington

41. Victoria Welding & Fabricating, Ltd.
Victoria, British Columbia
Canada

42. Washington Iron Works
Formac International, Inc.
Seattle, Washington

43. Western Gear Corporation
Everett, Washington

44. U A Pipefitting
Everett, Washington

45. Ace Seattle Corporation
Everett, Washington

Appendix E

NATIONALLY SELECTED CONTROL GROUP

(Jury of Experts)

1. Warren Borges
General Electric Company
Lynn, Massachusetts 01933

2. Walter A. Bowman
U.S. Steel Corporation
600 Grant Street
Pittsburgh, Pennsylvania 15230

3. A.J. Dearing, Assistant Manager
Welding Research & Development
A.O. Smith Corporation
P.O. Box 584
Milwaukee, Wisconsin 53201

4. John H. Forrer
Welding Consultant
Welding Technology, Inc.
Everett, Washington 98201

5. Martin Gans
Gans Test Equipment, Ltd.
15 East 6th Avenue
Vancouver 10, British Columbia
Canada

6. Frederick D. Houck
Engineering Consultant Chairman
Central Arkansas Section AWS
19 Leslie Circle
Little Rock, Arkansas 72205

7. Richard Johnson
Weld Shop Foreman
Reserve Mining Company
Silver Bay, Minnesota 55614

8. J.W. Mitchell, Manager
Welding Development Department
Manufacturing Development Office
Ford Motor Company
24500 Glendale
Detroit, Michigan 48239

9. John W. Moeller
Chief Welding Engineer
R.M. Parsons Company
P.O. Box 54802
Los Angeles, Calif. 90054

10. B.O. Mueller
Manitowoc Shipbuilding, Inc.
500 South 16th Street
Manitowoc, Wisconsin 54220

11. Ray S. Parrott
Welding Superintendent
New Construction
Building 16, Mail Route 7
National Steel & Shipbuilding Company
Harbor Drive & 28th Street
San Diego, California 92112

12. Donald Price
Construction Engineer
Weyerhaeuser Company
Longview, Washington 98632

Appendix F, Part I, (Welders)

TYPE OF PRODUCTS MANUFACTURED BY INDUSTRIES REPRESENTED WITHIN STUDY

1. Maintenance and repair of heavy equipment.
2. Stainless steel fittings.
3. Concrete pipe and welded steel pipe.
4. IRR Power saws.
5. Corrugated steel products.
6. Machine tools.
7. Castings.
8. Coil springs, auto, truck, and large sizes.
9. Aerospace.
10. SPAM and Minute Man.
11. Metal food can containers.
12. Electric steel foundry products.
13. Arch - aluminum and steel.
14. General marine - boat building and repair.
15. Rail cars, barges and oil tankers.
16. Underground mining equipment.
17. Trucks. (three industries)
18. Tractors and trucks. (two industries)
19. Equipment - roads, mills, and mine.
20. Ship repair.
21. Structural steel, air pollution equipment machinery.
22. Ship building. (two industries)

23. ASME Code vessels.

24. Boilers, pressure vessels, and general metal fabrication.

25. Pipeline construction, pipe fabrication and pipe erection.

26. Aluminum production.

27. Container cranes.

28. Heavy construction.

29. Logging equipment, board pressures, cranes, cable ways, etc.

Appendix F, Part 2 (Welding Supervisors)

TYPE OF PRODUCTS MANUFACTURED BY INDUSTRIES REPRESENTED WITHIN STUDY (Continued)

Number of Industries	Percentage	
7	17	Cars, trucks, forklift trucks, railroad cars
5	12.5	Shipyards and shipyard maintenance
2	5	Atomic energy
7	17	Custom metal products and heavy machinery
4	10	Lumber and container handlers
4	10	Casting Industries - iron, steel, stainless steel, titanium & super alloys
1	2.5	Springs (leaf and coil)
2	5	Aluminum and copper products
3	7.5	Container products - boilers, nuclear, petroleum and water
2	5	Structural steel
3	7.5	Pipe - aluminum, steel and reinforced concrete
1	2.5	Education facilities

Appendix F, Part 3 (Control Group

3	25	Cars, trucks, forklift trucks and railroad cars
2	16	Shipyards and shipyard maintenance
1	8	Contain products - boilers, nuclear, petroleum and water
2	16	Structural steel
3	25	Engineering and welding consultants
1	8	Mining industries

Appendix G, Part 1

INFORMATION SEEKING LETTER

11003 - 23rd Drive Southeast
Everett, Washington 98204
November , 1973

Gentlemen:

This writer is currently on leave from his welding instruction duties at Everett Community College, Everett, Washington to conduct research of welding technology and a task analysis of industrial production welders, under the direction of Dr. Athol R. Baily at the University of Washington. This research will provide information from which schools of welding technology may review and update their curriculums.

In pursuit of this goal, I have need of current bibliographies, research bulletins, documents, and publications relative to welding technology.

If you have materials of this nature, I would appreciate knowing if they are available, and how I may arrange for their use.

Thank you,

Charles F. Bacon

Appendix G, Part 2

COVER LETTER AND PRELIMINARY QUESTIONNAIRE

11003 - 23rd Drive Southeast
February , 1974

Dear Sir:

To enable schools of welding to reflect industrial changes, an indepth study of welding technology and the welder's task is essential.

In pursuit of this goal, I am initiating a study of the welder's tasks as reported by a production welder and a welding supervisor. If you employ welders and feel that they schould be more adequately trained, will you please assist in this study by allowing a welder and a welding supervisor to fill out the respective enclosed questionnaires and have them returned to me in the self-addressed stamped envelopes provided.

This writer is currently on leave from his welding instruction duties at Everett Community College and is conducting this research under the direction of Dr. Athol R. Baily at the University of Washington.

Your cooperation in this project will be greatly appreciated and a summary of the research will then be provided you on its completion.

Thank you,

Charles F. Bacon

PRELIMINARY QUESTIONNAIRE

1. Please give any name and address correction required and person to whom this correspondence should be directed within your industry. ________________________________

   ____

   ____

   ____

2. Does your industrial concern employ welders? yes ______ no ______

3. What percentage of your welders are hired directly upon graduation from vocational welding schools? __________

4. Do you feel that welders should be more adequately trained by the schools for your welding needs? yes _____ no _____

5. Information from which revised welding curriculum may be developed to reflect your industrial needs can be provided by your allowing a typical production welder and a welding supervisor to fill out a questionnaire describing their duties.

   Will you assist in this endeavor? Yes ______ no ______

   (Comments you may wish to make)

   ____

   ____

   ____

   ____

   Please return your response in self-addressed stamped envelope.)

Appendix G, Part 3

CONTROL GROUP COVER LETTER

11003 - 23rd Drive Southeast
Everett, Washington 98204
January , 1974

Dear Sir:

To enable schools of welding to reflect industrial changes an indepth study of welding technology and the welder's task is essential.

In pursuit of this goal, I am initiating a study of the welder's task as reported by welders and welding supervisors in the Pacific Northwest Region. To provide greater validity for this study, you have been selected from nationally known welding or welding related personnel to serve as a member of a jury of experts. Will you please assist in this endeavor by filling out the enclosed questionnaire and returning to me in the self-addressed stamped envelop provided.

This writer is currently on leave from his welding instruction duties at Everett Community College and is conducting this research under the direction of Dr. Athol R. Baily at the University of Washington.

Your cooperation in this project will be greatly appreciated and a summary of the research will then be provided you on its completion.

Thank you,

Charles F. Bacon

Dear Sir:

This questionnaire is designed to provide information of the weldor's tasks to enable schools of welding to update their welding curriculums. In pursuit of this goal, I am on leave from my welding instruction duties at Everett Community College and am under the direction of Dr. Athol R. Baily at the University of Washington.

Your cooperation in this study is essential and will be greatly appreciated. Should you desire, a summary of this research will be provided you upon its completion. _____ yes _____ no

Thank you,
Charles F. Bacon
Charles F. Bacon

GENERAL INFORMATION: (weldor)

1. Respondent's name ____
2. Name of industry ____
3. Type of products manufactured ____________________________________
4. Employment entry skill level:
   a. Experience __________ years
   b. Welding test or certification required ________________________ __________ (5-6)
5. Union affiliation ____________________________ check if not required ____________
6. Physical examination required for employment ______ yes ______ no (7)
7. By which of the below listed weldor employment recruiting procedures did you secure your present employment? (8)
   a. State employment services _____________
   b. Private employment services ____________
   c. Advertisements in local papers ___________
   d. Union halls _______________________
   e. Welding schools ____________________
   f. If other, list ____
   ____
   ____
8. Highest educational grade level completed ______________________________ (9-10)
9. Your welding training was provided by: (11)
   a. Community College __________________
   b. Vocational school ___________________
   c. High school ________________________
   d. Other ____________________________
10. Was your vocational welding training adequate for your entry level employment needs? (12)
    yes _______ no _______
    a. If answer was no, please list areas of deficiency in space provided.
    ____
    ____
    ____
    ____

(Numbers to the right, in parentheses, are for computer use only.)

DIRECTIONS (for the following section of questionnaire):

Evaluate the following statements in terms of their importance to a student preparing for employment in your industrial concern as a production weldor with respect to his ability to perform.

Circle your choice of response in the space provided whether it is necessary (N), desirable (D), or unnecessary (U) for weldors to receive training in the following subject areas.

EXAMPLE:				
1. Ability to make a butt weld	N	D	U	
BASIC EDUCATION:				
11. Mathematical problem solving ability encompassing arithmetic through basic algebra.	N	D	C	(13)
12. Basic understanding and application of scientific laws as related to mechanics; i.e. (levers).	N	D	C	(14)
13. Human relations:				
a. Weldor—supervisor relations	N	D	U	(15)
b. Weldor—fellow work man relations	N	D	U	(16)
c. Weldor—society relations	N	D	U	(17)
14. Communications:				
a. Write reports	N	D	U	(18)
b. Verbally direct others	N	D	U	(19)
c. Receive verbal communications	N	D	U	(20)
15. Economics as related to:				
a. Employment	N	D	U	(21)
b. Income and Taxes	N	D	U	(22)
c. Industrial organizations	N	D	U	(23)
d. Family finance management	N	D	U	(24)
WELDING RELATED KNOWLEDGE REQUIREMENTS:				
16. Interpret blueprints, shop drawings and welding symbols.	N	D	U	(25)
17. Ability to make simple pictorial and three view drawings.	N	D	U	(26)
18. Ability to interpret and use drawings related to hydraulic and pneumatic systems.	N	D	U	(27)
19. Ability to interpret and use electrical drawings related to welding equipment.	N	D	U	(28)
20 Knowledge of weld characteristics of:				
a. Low and medium carbon steel	N	D	U	(29)
b. Low alloy steels: i.e. (T1)	N	D	U	(30)
c. High alloy steels: i.e. (347)	N	D	U	(31)
d. Aluminum alloys	N	D	U	(32)
e. Magnesium alloys	N	D	U	(33)
f. Titanium alloys	N	D	U	(34)
g. Other	N	D	U	(35)
	N	D	U	(36)

21. Heat treating of metals:				
a. Annealing	N	D	U	(37)
b. Normalizing	N	D	U	(38)
c. Hardening	N	D	U	(39)
d. Tempering or drawing	N	D	U	(40)
22. Understanding of electricity as related to:				
a. AC-DC rectifier welding power source	N	D	U	(41)
b. Motor-generator welding power source	N	D	U	(42)
c. Alternating current power source	N	D	U	(43)
23. Characteristics of metals as related to weldability, melting point, yield point, tensile strength, brittieness, expansion and contraction.	N	D	U	(44)
24. Understanding of design for welded structure.	N	D	U	(45)
25. Understanding of basic type joints and their characteristics when welded.	N	D	U	(46)
26. Welding and its affect upon heat-treated metals.	N	D	U	(47)
27. Understanding of the terms and processes of welding.	N	D	U	(48)
28. Understanding of the characteristics of a quality weld.	N	D	U	(49)
29. Understanding of the testing and inspection process.	N	D	U	(50)
30. Understanding of welding related cost factors.	N	D	U	(51)
31. Production related:				
a. Understanding of the possibilities and limitations of various cutting processes with respect to metals and their alloys used in industry.	N	D	U	(52)
b. Understanding of the codes and specifications related to welding; such as pressure vessels, piping, building safety, etc.	N	D	U	(53)
c. Understanding of welding sequences as related to distortion.	N	D	U	(54)
d. An awareness of hazardous fumes and gases when welding on certain materials.	N	D	U	(55)

WELDORS RELATED SKILLS AND FUNCTIONS

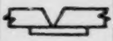
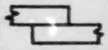
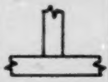
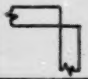
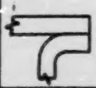
32. Equipment operation

a. Press brake	N	D	U	(44)
b. Punch	N	D	U	(45)
c. Band saw	N	D	U	(46)
d. Grinders and sanders	N	D	U	(47)
e. Squaring shear, brade, nibbler,etc.	N	D	U	(48)
f. Efficient use of small hand tools	N	D	U	(49)
g. Drilling equipment	N	D	U	(50)
h. Lathe, shaper, mill, etc.	N	D	U	(56)
i. Jigs-fixtures	N	D	U	(57)
j. Power shear	N	D	U	(58)
k. Hydraulic lifts	N	D	U	(59)
l. Pneumatic systems	N	D	U	(60)
m. Taps, dies, reamers	N	D	U	(61)
n. Others	N	D	U	(62)

33. Welding related functions:

a.	Oxyacetylene gouging	N	D	U	(63)
b.	Arc gouging	N	D	U	(64)
c.	Machine cutting	N	D	U	(65)
d	Repair welding machines	N	D	U	(66)
e.	Read and interpret prints for job	N	D	U	(67)
f.	Perform job layout	N	D	U	(68)
g.	Fit up for job	N	D	U	(69)
h.	Repair welding machine leads and grounds	N	D	U	(70)
i.	Select materials for job	N	D	U	(71)
j.	Select electrodes for job	N	D	U	(72)
k.	Perform Hard-facing	N	D	U	(73)
l.	Position for welding	N	D	U	(74)
m.	Heat treating of metals	N	D	U	(75)
n.	Metal spraying and finishing	N	D	U	(76)
o.	Automated equipment welding related	N	D	U	(77)

MANIPULATIVE SKILLS FOR A PRODUCTION WELDOR

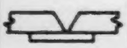
34. Check in spaces provided for each type of joint:		butt				lap				fillet				corner				edge				
																						
	Weld process	oxy	arc	TIG	MIG	oxy	arc	TIG	MIG	oxy	arc	TIG	MIG	oxy	arc	TIG	MIG	oxy	arc	TIG	MIG	
	(computer use)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
a. In columns below each joint check positions weld process is used.	Flat weld																					(a)
	Horizontal																					(b)
	Vertical																					(c)
	Overhead																					(d)
b. In columns below each type of joint check processes used for weave or stringer beads.	Stringer beads																					(e)
	weave																					(f)
	other																					(g)

(Space for additional comments you may wish to make.)

MANIPULATIVE SKILLS FOR A PRODUCTION WELDOR (Continued)

35. Check in space provided opposite each type of joint:
   a. Check type of weld used for each joint show: i.e. (weave).
   b. Check electrodes used for each type of joint in columns opposite size shown.

36. In column opposite type of joint check:
   a. Metal thickness used.
   b. Metal shapes used.
   c. Type of metal used.

	a.		b.								a.				b.					c.							
	Stringer	Weave	E6010	E6011	E6012	E6013	E7018	E7024	E7028	Electrode size	Sheet metal	3/16-1/4	5/16-3/8	1/2 and thicker	Pipe	Angle	Channel	"I" beam	Round	Mild steel	Low alloy	High alloy	Aluminum	Titanium			
	1	2	3	4	5	6	7	8	9		10	11	12	13	14	15	16	17	18	19	20	21	22	23			
Butt 										3/32																	h
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										5/32																	j
										3/16																	k
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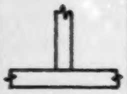
Fillet 										3/32																	m
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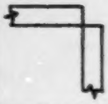
Corner 										3/32																	r
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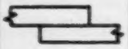
Lap 										3/32																	w
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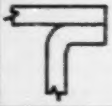
Edge 										3/32																	B
										1/8																	C
										5/32																	D
										3/16																	E
										1/4																	F

Dear Sir:

This questionnaire is designed to provide information of the weldor's tasks to enable schools of welding to update their welding curriculums. In pursuit of this goal, I am on leave from my welding instruction duties at Everett Community College and am under the direction of Dr. Athol R. Baily at the University of Washington.

Your cooperation in this study is essential and will be greatly appreciated. Should you desire, a summary of this research will be provided you upon its completion. ______yes ______no

Thank you,

Charles F Bacon

Charles F. Bacon

GENERAL INFORMATION: (Supervisor of weldors)

1. Respondent's name ______________________________
2. Name of industry ______________________________
3. Type of products manufactured ______________________________
4. Weldor employment entry skill level requirements: (5)
   a. Experience ______________
   b. Welding test or certification required ______________________________
5. Union affiliation ______________________________
6. Number of weldors employed ______________ (6-7)
7. Physical examination required for employment __________yes __________no (8)
   other ______________________________
8. By which of the following methods are weldors recruited for employment? (9)
   a. State employment service ______________
   b. Private employment service ______________
   c. Advertisements in local papers ______________
   d. Union halls ______________
   e. Welding schools ______________
   f. If other, list ______________________________
   ____
9. Do you have any general education grade level requirements. __________ yes (10)
   __________ no. If yes, please list ______________________________
10. Your weldors were trained principally by: (11)
    a. Community college ______________
    b. Vocational schools ______________
    c. High school vocational programs ______________
    d. Other ______________
11. Was the vocational welding training adequate for your weldor's entry level employment needs? __________ yes __________ no (12)
    a. If your answer was no, please list areas of deficiency in the space provided. __________
    ____

(Numbers to the right in parentheses are for computer use only.)

12. Please list within your industrial concern the job levels of personnel who are employed in weldor occupations by skill level, that is,

"tacker" tacks mild steel in flat, horizontal, vertical and O/H positions

DIRECTIONS: (For the following section of questionnaire.)

Evaluate the following statements in terms of their importance to a student preparing for employment in your industrial concern as a production weldor with respect to his ability to perform.

Circle your choice of response in the space provided whether it is necessary (N), desirable (D), or unnecessary (U) for weldors to receive training in the following subject areas.

EXAMPLE:				
1. Ability to make a butt weld	N	D	U	
BASIC EDUCATION:				
13. Mathematical problem solving ability encompassing arithmetic through basic algebra.	N	D	U	(13)
14. Basic understanding and application of scientific laws as related to mechanics: i.e. (levers).	N	D	U	(14)
15. Human relations:				
a. Weldor - supervisor relations	N	D	U	(15)
b. Weldor - peer relations	N	D	U	(16)
c. Weldor - society relations	N	D	U	(17)
16. Communications:				
a. Write reports	N	D	U	(18)
b. Verbally direct others	N	D	U	(19)
c. Receive verbal communications	N	D	U	(20)
17. Economics as related to:				
a. Employment	N	D	U	(21)
b. Income and taxes	N	D	U	(22)
c. Industrial organizations	N	D	U	(23)
d. Family finance management	N	D	U	(24)
WELDING RELATED KNOWLEDGE REQUIREMENTS:				
18. Interpret blueprints, shop drawings and welding symbols.	N	D	U	(25)
19. Ability to make simple pictorial and three view drawings.	N	D	U	(26)
20. Ability to interpret and use drawings related to hydraulic and pneumatic systems.	N	D	U	(27)
21. Ability to interpret and use electrical drawings related to welding equipment.	N	D	U	(28)

WELDING RELATED KNOWLEDGE REQUIREMENTS: (Continued)

22. Knowledge of the welding characteristics of:				
a. Low and medium carbon steel	N	D	U	(29)
b. Low alloy steels: i.e. (T1)	N	D	U	(30)
c. High alloy steels: i.e. (347)	N	D	U	(31)
d. Aluminum alloys	N	D	U	(32)
e. Magnesium alloys	N	D	U	(33)
f. Titanium alloys	N	D	U	(34)
g. Other	N	D	U	(35)
	N	D	U	(36)
23. Heat treating of metals:				
a. Annealing	N	D	U	(37)
b. Normalizing	N	D	U	(38)
c. Hardening	N	D	U	(39)
d. Tempering or drawing	N	D	U	(40)
24. Understanding of electricity as related to:				
a. AC-DC rectifier welding power source	N	D	U	(41)
b. Motor-generator welding power source	N	D	U	(42)
c. Alternating current power source	N	D	U	(43)
25. Characteristics of metals as related to weldability, melting point, tensile strength, brittleness, yield point, expansion and contraction.	N	D	U	(44)
26. Understanding of design for welded structure.	N	D	U	(45)
27. Understanding of basic type joints and their characteristics when welded.	N	D	U	(46)
28. Welding and its affect upon heat-treated metals.	N	D	U	(47)
29. Understanding of the terms and processes of welding.	N	D	U	(48)
30. Understanding of the characteristics of a quality weld.	N	D	U	(49)
31. Understanding of the testing and inspection process.	N	D	U	(50)
32. Understanding of welding related cost factors.	N	D	U	(51)
33. Production related:				
a. Understanding of the possibilities and limitations of various cutting processes with respect to metals and their alloys used in industry.	N	D	U	(52)
b. Understanding of the codes and specifications related to welding; such as, pressure vessels, piping, building safety, etc.	N	D	U	(53)
d. Understanding of welding sequences as related to distortion.	N	D	U	(54)
e. An awareness of hazardous fumes and gases when welding on certain materials.	N	D	U	(55)

FUTURE WELDING TRENDS:

DIRECTIONS: (For the following section of questionnaire.)

Evaluate the following statements as to the influence future welding trends will have on o industry and welding training.

34. The Weldor:

a. Forecasts indicate great numbers of new weldors shall be needed by industry. Where may these people best be trained? (Check answer or answers.) (56)

(1) High school vocational welding classes ________________

(2) Private vocational welding classes ________________

(3) Post high school vocational welding classes ________________

(4) A combination of the three above methods plus industry providing additional on the job training relative to their particular needs. ________________

(5) Private industry train their own people. ________________

(6) Other ________________

____

____

35. Weld Process:

a.	Oxy-acetylene	increase	______	decrease	______	other	________	(57)
b.	Metallic arc	"	______	"	______	"	________	(58)
c.	Gas metal arc (solid core)	"	______	"	______	"	________	(59)
d.	Gas metal arc (inner shield)	"	______		______		________	(60)
e.	Tungsten inert-gas arc	"	______	"	______	"	________	(61)
f.	Plasma arc	"	______	"	______	"	________	(62)
g.	Ultra sonic	"	______	"	______	"	________	(63)
h.	Other ________	"	______	"	______	"	________	(64)
i.	________		______		______		________	

36. Should welding schools be involved with weldor certification (65)

______ yes ______ no

37. Should welding schools be involved with the teaching of welding code requirements. (66)

______ yes ______ no

(Comments you may wish to make.) ________________

____

____

____

____

38. Should welding schools enter into more cooperative educational programs with industry employing weldors? (67)

______ yes ______ no ______ Other. If yes, please list suggestions for implementing.

____

____

____

____

TABLE IV

COMPARATIVE TABULATION OF THE NEEDS AND REQUIREMENTS FOR THE TRAINING OF WELDING OPERATORS

10 In a proposed post high school curriculum, evaluate the importance of each subject area for the following position.

	Industry				Jury			
	Total	N %	D %	U %	Total	N %	D %	U %
Communications:								
a Reading	37	86.5	10.7	2.8	15	66.7	13.3	20.0
b Report Writing	36	5.6	41.6	52.8	14	21.6	42.7	35.7
c Speech	37	18.9	51.4	29.7	15	13.3	46.7	40.0
Mathematics:								
a Trigonometry	27	11.1	63.0	25.9	16	37.5	6.3	56.2
b Algebra	36	5.6	41.7	52.7	13	30.8	7.7	61.5
c Analytical Geometry	36		19.4	80.6	15	6.7	13.3	80.0
d Calculus	36		5.5	94.5	14			100.0
Chemistry	36	11.2	36.1	52.7	15	20.0	26.7	53.3
Physics	34	2.9	50.0	47.1	14	14.4	42.8	42.8
Metallurgy	35	14.3	74.3	11.4	16	25.0	62.5	12.5
Psychology	37		21.5	78.5	15	6.7	13.3	80.0
Political Science	36	2.8	16.7	80.5	15	6.7	13.3	80.0

TABLE IV (continued)

	Welder							
	Industry				Jury			
	Total	N	D	U	Total	N	D	U
		%	%	%		%	%	%
Industrial Safety	38	60.5	34.2	5.3	14	71.4	21.5	7.1
Engineering Drawing	36	27.8	58.4	13.8	15	26.7	60.0	13.3
Blueprint Development and Reading	28	46.5	50.0	3.5	16	75.0	25.0	
Electric Machines and Controls	35	14.4	57.2	28.4	16	37.5	50.0	12.5
Electric Current Theory	36	11.2	47.3	41.5	15	26.7	60.0	13.3
Labor and Management	37	16.2	32.4	51.4	15	6.7	60.0	33.3
Welding Theory	37	64.9	29.7	5.4	15	73.3	20.0	6.7
Strength of Materials	37	32.4	46.0	21.6	16	31.2	50.0	18.8
Non-destructive Testing	37	13.5	64.9	21.6	16	31.3	56.2	12.5
Physical Education	35	17.3	17.3	65.4	14	28.5	7.2	64.3
Basic Machine Technology	32	21.8	46.9	31.3	16	31.3	50.0	18.7
Welding Applications	38	60.5	39.5		16	87.5	12.5	

TABLE IV (continued)

	Welder							
	Industry				Jury			
	Total	N %	D %	U %	Total	N %	D %	U %
Oxy-acetylene Welding	36	75.0	25.0		16	87.5	12.5	
Arc Welding	37	92.0	8.0		16	100.0		
Inert Gas Welding (Mig and Tig)	35	65.7	34.3		15	100.0		
What Graduates Should Know:								
11 Welding Processes:								
Oxy-acetylene Welding	36	83.3	16.7		16	81.3	12.5	6.2
Shielded Metal Arc Welding	37	83.7	16.3		15	100.0		
Atomic Hydrogen Welding	35	20.0	51.5	28.5	14	14.3	35.7	50.0
Carbon Arc Welding	37	48.6	43.3	8.1	14	28.6	42.8	28.6
Tungsten Inert-gas Arc Welding	36	55.6	36.2	8.2	15	100.0		
Metallic Inert-gas Arc Welding	34	55.9	41.2	2.9	16	87.5	6.2	6.3
Short Arc Process	35	48.6	42.8	8.6	15	73.3	13.3	13.4
Submerged Arc Process	33	45.4	48.5	6.1	15	60.0	26.7	13.3

TABLE IV (continued)

	Welder							
	Industry				Jury			
	Total	N	D	U	Total	N	D	U
		%	%	%		%	%	%
Plasma-Arc Process	33	18.1	66.6	15.3	14	28.6	42.8	28.6
Resistance Welding	34	50.0	38.2	11.8	14	42.8	42.9	14.3
Surfacing and Metallizing	32	37.5	50.0	12.5	14	57.2	21.4	21.4
Cutting:								
a Oxy-acetylene Machine	36	63.9	33.4	2.7	16	81.3	12.5	6.2
b Oxy-acetylene Manual	34	73.6	26.4		15	86.5	13.5	
c Powder Cutting Process	36	30.5	58.4	11.1	15	60.0	20.0	20.0
d Arc Cutting Process	36	55.5	44.5		15	60.0	20.0	20.0
12 Nature of Steel and Iron:								
a Process of Making Steel	36	5.5	61.2	33.3	16	31.2	37.6	31.2

TABLE IV (continued)

	Welder							
	Industry				Jury			
	Total	N %	D %	U %	Total	N %	D %	U %
b Physical properties of ferrous metals important to the welding process such as weldability, ductility, melting point, yield point, tensile strength, brittleness, expansion and contraction	35	40.0	54.3	5.7	16	62.5	37.5	
13 Complete understanding of welding symbols	37	89.2	10.8		16	75.0	25.0	
14 Understanding of the hard surfacing process and materials	37	40.5	54.2	5.3	16	43.8	50.0	6.2
15 Understanding of design for welded structures	33	15.3	57.4	27.3	16	18.7	62.5	18.8
16 Understanding of basic type joints and their characteristics when welded	37	65.0	29.7	5.3	16	62.5	31.3	6.2

TABLE IV (continued)

		Welder							
		Industry				Jury			
		Total	N	D	U	Total	N	D	U
			%	%	%		%	%	%
17	Welding and its effects upon heat-treated metal	36	52.7	41.7	5.6	16	50.0	50.0	
18	Understanding of the terms and processes of welding	37	73.0	27.0		16	75.0	25.0	
19	Understanding of the characteristics of a quality weld	36	91.7	8.3		16	93.8	6.2	
20	Understanding of testing and inspection process	36	33.4	55.6	11.0	16	25.0	62.5	12.5
21	Factors of cost involved in bidding on welding jobs	37	5.4	51.4	43.2	16	6.2	43.8	50.0
22	Understanding of electricity concerning the welding circuit and its effects upon welding	36	38.9	47.2	13.9	16	37.5	50.0	12.5
23	Understanding of the principles of flame cutting and its application to manual and machine cutting	36	61.1	38.9		16	75.0	12.5	12.5

TABLE IV (continued)

		Welder							
		Industry				Jury			
		Total	N	D	U	Total	N	D	U
			%	%	%		%	%	%
24	Understanding of the effect of flame cutting on metals and their cutability	36	52.8	41.7	5.5	16	75.0	25.0	
What Graduates Should be Able to Do:									
25	Observe proper safety precautions involving the use of arc welding equipment	37	94.5	5.5		16	100.0		
26	Operate and maintain arc welding equipment	37	75.6	24.4		16	81.3	12.5	6.2
27	Select the correct arc welding electrode for each job	37	75.6	24.4		16	75.0	25.0	
28	Pass welding certification tests in the various welding positions	37	81.1	13.5	5.4	16	100.0		

TABLE IV (continued)

		Welder							
		Industry				Jury			
		Total	N	D	U	Total	N	D	U
			%	%	%		%	%	%
29	Observe the necessary safety precautions when using oxygen and acetylene in the welding and cutting process	37	89.2	10.8		16	100.0		
30	Select the proper welding flux for each job	37	81.1	18.9		16	62.2	31.2	6.6
31	Make satisfactory welds on ferrous metals in all positions	37	94.6	2.7	2.7	16	100.0		
32	Weld pipe and sheet metal in all standard type of joints	35	83.0	14.2	2.8	16	100.0		
33	Braze and braze weld	37	62.2	27.0	10.8	11	91.0	9.0	
34	Make aircraft type tubular joints	35	37.2	40.0	22.8	16	50.0	25.0	25.0
35	Do fusion welding of cast iron	35	48.5	37.2	14.3	16	62.5	25.0	12.5

TABLE IV (continued)

		Welder							
		Industry				Jury			
		Total	N	D	U	Total	N	D	U
			%	%	%		%	%	%
36	Do fusion welding of stainless steels	36	58.4	33.3	8.3	16	87.7	6.7	6.6
37	Do welding of aluminum alloys	36	66.6	30.6	2.8	16	87.5	12.5	
38	Apply hard surfacing materials	36	52.8	38.9	8.3	16	56.2	37.2	6.6
39	Make drawings and blueprints	36	5.5	38.9	55.6	16	6.6	43.4	50.0
40	Read and interpret blueprints and other related specifications	37	67.6	32.4		16	62.2	31.2	6.6

1974 WELDING TASK ANALYSIS

by

Charles Frederick Bacon

An abstract of a post masters study
conducted for the purpose of updating
welding technology curriculum.

University of Washington

1974

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1974 WELDING TASK ANALYSIS

Charles Frederick Bacon
This research supervised by Dr. Athol R. Baily, Ed. D.

This post masters degree research has been conducted for the purpose of providing current empirical data from which relevant welding curriculums may be updated.

Current welding occupational research does not exist or is limited in scope.

Job classifications do not accurately reflect "welding job" functions; therefore, the development of curriculum and the training of welders may or may not be relevant. This study has sought information to provide for:

1. Updating of welding curriculums.
2. Establishment of an occupational ladder.
3. To seek the commonalities among the many facets of welding in the various metal industries.

The first stage of the descriptive survey was sent to all potential industry employing welders within Washington State, Portland, Oregon, and Vancouver, British Columbia, requesting their cooperation that an indepth questionnaire be filled out by a welder and a welding supervisor. The five questions sought the following information:

1. Correct name and address of industry.
2. Do you hire production welders?
3. What percent of welders do you hire from vocational schools?
4. Do you feel they should be more adequately trained?
5. Will you allow a welder and welding supervisor to fill out an information seeking questionnaire?

The second stage of the survey consisted of two detailed questionnaires, one for the welder and theother for the welding supervisor. The welders' questionnaire consisted of thirty-six statements divided into five sections: general information, basic education, welding related knowledge requirements, welders' related skills and functions, and the manipulative skills for a production welder. The welding supervisors' questionnaire consisted of thirty-eight statements divided into four sections: general information, basic education, welding related knowledge requirements, and future welding trends.

To provide a comparative base for evaluation of data, the welding supervisors' questionnaire was mailed to regional American Welding Society presidents throughout the United States and other selected industries.

For additional information the writer initiated a computer search "Eric" for related research, library research, personal interviews, and relied on the writer's own personal experiences. The questionnaires were designed for computer utilization to provide for numerical computation of all data.

The second chapter has provided an account of related research relevant to this study.

Chapter three has provided a summary of the preliminary questionnaire data. The results have indicated 29 or 42% of the respondents do not hire any welders from vocational welding schools. There were 54 or 87% of the respondents who felt welding schools should do a better job of training welders for their employment needs.

Chapter four has provided an analysis of the in-depth questionnaire filled out by the welders.

Chapter five has provided a comparative analysis from data supplied by the regional welding supervisors and the nationally selected control group.

Chapter six has provided a comparative summary analysis of all data from the regional welders, welding supervisors and the nationally selected control group. A brief comparative analysis has been provided concerning current data from this study with data provided by the Bacon 1964 thesis on the welder's educational needs.

Following the summary of data within Chapter six, the following conclusions were drawn:

1. Large percentages of industry do not hire any welders directly from vocational welding schools.
2. Many respondents felt the schools should do a better job of training welders for their industrial needs.
3. The need exists for greater industry-welding school cooperation for the training of welders. The anticipated need for large numbers of new welders could best be met by cooperative training programs with industry providing the final training aspects peculiar to their respective needs.
4. The largest percent of welders were trained by vocational welding schools.
5. Welding schools should teach welding related certification requirements for the welder but should not become certification stations.
6. The trainee welder should be taught general information relative to welding code requirements.
7. Welders need to know how to make and use welding drawings and symbols.

8. Basic education involving mathematics, scientific laws of mechanics, human relations, communications, and economics related to employment and home was thought to be desirable knowledge for all welders.

9. Welders need to know and understand the metallurgical characteristics of common metals and the effects of welding on them.

10. Welders were expected to know and understand the characteristics of a quality weld, welding sequences, welding processes, testing and inspection procedures, and weld-joint design and their welding characteristics.

11. Welders should have a working knowledge of most welding related equipment operation and specifically of grinders, sanders, hand tools, jigs-fixtures, and taps, dies and reamers.

12. Welders should be able to arc gouge, fit up and position for job, and select electrodes and materials for the job.

13. Welders should possess certifiable skills on common metals, types of welds and joints, filler metals and processes with some experience in the unusual as related to out of position, poor fit up etc.

14. The occupational ladder for industrial welders varies greatly throughout industry or does not exist.

15. Oxy-acetylene welding should no longer be considered an industrial welding process.

16. Welding related aspects of safety should be known and understood by all welders.

17. The majority of welders are high school graduates.

18. Of the various regional industrial welder recruitment procedures, the largest percentage were recruited through the union halls.

19. Most welders are required to be affiliated with one of the several unions having jurisdiction of welders.

20. The majority of industry employing welders have no physical examination requirements.

The appendixes were included to provide the reader with specific and general comments and tables from the welders, welding supervisors, and the control group questionnaires. Appendix A with Parts 1 and 2 has all comments and data relative to the preliminary questionnaire. Appendix B provided with Parts 1 through 9 has provided for all comments and data tabulation relative to the welder. Appendix C with Parts 1a through 11a and 11b, has included the comparative data and tabulations for the regional welding supervisors and the national control group. Appendix D has provided a list of industrial concerns while Appendix E lists the nationally selected control group. Appendix F with Parts 1, 2, and 3, lists the types of products manufactured for each group listed separately. Appendix G lists information seeking letter, preliminary questionnaire, and the control group cover letter. Appendix H has included the welders' questionnaire, while Appendix I has provided the welding supervisors' control group questionnaire. Appendix J has included Table IV which has welder training data from the 1964 Bacon thesis on welding, University of Washington, Seattle, Washington.